AD-A115 779 CORPS OF ENGINEERS SEATTLE WA SEATTLE DISTRICT F/G 13/2
INTERIM FEASIBILITY REPORT AND DRAFT ENVIRONMENTAL IMPACT STATE--ETC(U)
JUN 82

UNCLASSIFIED NL

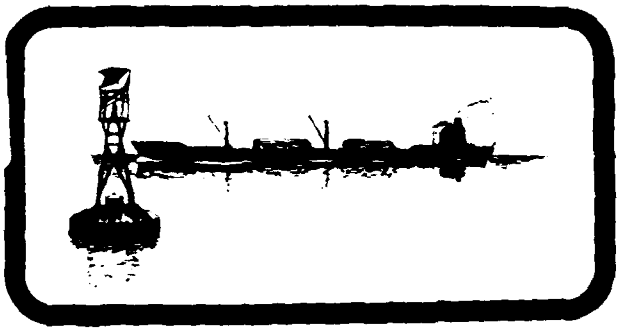
1 OF 6
AD A
115 779

43

(3)

INTERIM FEASIBILITY REPORT AND DRAFT ENVIRONMENTAL IMPACT STATEMENT

Grays Harbor, Chehalis and Hoquiam Rivers, Washington Channel Improvements for Navigation



DRAFT

US Army Corps of Engineers
Seattle District

JUNE 1982

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A115 779	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Interim Feasibility Report and Draft Environmental Impact Statement, Grays Harbor, Chehalis and Hoquiam Rivers, Washington, Channel Improvements for Navigation		5. TYPE OF REPORT & PERIOD COVERED Draft Report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Corps of Engineers, Seattle District P.O. Box C-3755 Seattle, WA 98124		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE June 1982
		13. NUMBER OF PAGES 520
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Grays Harbor	Federal Navigation Project	Navigation Improvement
Chehalis River	Commercial Waterway	Deep-Draft Shipping
Hoquiam River	Channel Improvements	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Conducted under the authority of resolutions of the Senate and House Public Works Committees, the study determined the need for and feasibility of improving the safety and efficiency of deep-draft water in Grays Harbor, Washington. Features of the tentatively recommended plan include the following:

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

o 24.3 miles of channel improvement from the outer bar through the harbor entrance and estuary past the city of Aberdeen and up the Chehalis River to the town of Cosmopolis (authorized channel depth would range from 46 feet at the outer bar and entrance to 38 feet through the estuary to Port of Grays Harbor terminals at Aberdeen and 36 feet above port terminals to Cosmopolis).

o Replacement of the Union Pacific Railroad (UPRR) bridge at Aberdeen.

o Construction of three turning basins (Hoquiam, Cow Point-Aberdeen, Elliott Slough above UPRR bridge).

o Mitigation of 4 acres of lost shallow water fish feeding habitat.

o Mitigation through dredge modification to avoid increased juvenile and adult crab mortalities from dredging.

o Improved aids to navigation.

o Open-water disposal of dredged material at the harbor entrance (Point Chehalis and South Jetty sites) and in the ocean (about 3½ miles from the harbor entrance).

Project cost estimate (October 1981 price level):

Federal	$68,200,000
Local	3,100,000
Total	$71,300,000

Benefit-to-cost ratio: 1.7 to 1.0.

THIS DOCUMENT CONTAINS THE DRAFT

Volume I

Feasibility Report
Environmental Impact Statement
Plates
Appendixes
- A Section 404(b)(1) and Preliminary Section 103 Evaluation
- B Study Coordination and Public Envolvement
- C Economic and Social Evaluation
- D Engineering, Design, and Cost Estimates

DRAFT

ENVIRONMENTAL IMPACT STATEMENT

GRAYS HARBOR & CHEHALIS & HOQUIAM RIVERS, WASHINGTON
CHANNEL IMPROVEMENTS FOR NAVIGATION PROJECT

Abstract: Improvement of the Federal navigation channel in Grays Harbor, Washington, would increase the efficiency and safety of waterborne commerce in Grays Harbor. Potential project impacts have necessitated preparation of this environmental impact statement. Alternatives considered in detail included no action and several dredge material disposal variations of a channel improvement plan. The improvement plan encompasses channel widening and deepening from outside the harbor entrance through the estuary and up the Chehalis River to Cosmopolis, Washington. Replacement of the Union Pacific Railroad bridge over the Chehalis River at Aberdeen, Washington also is part of the plan. All variations of the improvement plan would include water quality, biological and sediment monitoring, mitigation (by replacement) of 4 acres of shallow subtidal juvenile salmonid feeding and rearing area which will be deepened by dredging, mitigation (by avoidance) through equipment modification to avoid or substantially reduce the loss of Dungeness crab which could be associated with project construction. The Port of Grays Harbor is the local sponsor for the project. The recommended (REC) plan includes open-water disposal of dredged material in both Grays Harbor and the Pacific Ocean; the least environmentally damaging (LED) plan would make greater use of clamshell dredges and would use only ocean disposal for dredged material; and the national economic development (NED) plan incorporates greater use of Grays Harbor estuary disposal, ocean disposal closer to the harbor entrance, than the REC or LED plans and would include some upland disposal of dredged material. The following unavoidable impacts associated with the REC plan after mitigation would be temporary: Loss to the channel benthos due to dredging, loss to benthos at disposal sites due to burial, degradation of water quality in the immediate dredging and disposal locations, displaceent of rockfish at South Jetty, and possible resuspension and recirculation of some silts within the estuary due to disposal of fines at South Jetty.

Without mitigation the major environmental impacts associated with the REC Plan would include removal of 4 acres of inner harbor juvenile salmonid feeding and rearing area and dredging-related mortality of an estimated .92 to 3.17 percent per year reduction in the number of Dungeness crabs harvested by the crab fishery at Westport, Washington, during initial dredging and several years following, and 2.6 percent harvest reduction associated with long-term loss for maintenance dredging. Without mitigation the major environmental impacts associated with the NED plan would be similar to the REC plan with the exception that an estimated 1.15 to 3.96 percent per year reduction would occur in the number of harvested Dungeness crabs in Westport due to initial dredging,

3.19 percent reduction due to long-term maintenance dredging. The impacts associated with the LED plan without mitigation would also be similar to those described for the REC plan with the exception that an estimated .55 to 1.90 percent per year reduction in the number of harvested Dungeness crabs would occur due to initial dredging and 1.53 percent due to long-term maintenance dredging

The lead agency is the U.S. Army Corps of Engineers, Seattle District.

SEND YOUR COMMENTS TO
THE DISTRICT ENGINEER
BY 26 JUL 1982

If you would like further information, please contact:

F. J. Urabeck, Chief
Navigation and Coastal Planning Section
U.S. Army Corps of Engineers, Seattle District
Post Office Box C-3755
Seattle, Washington 98124
Commercial Telephone (206) 764-3708
FTS Telephone 399-3?53

EXECUTIVE SUMMARY

The purpose of this study was to investigate the need for and feasibility of widening and deepening the existing Federal deep-draft navigation channel at Grays Harbor on the Washington Coast. The existing channel extends from the Pacific Ocean through Grays Harbor up the Chehalis River to Cosmopolis (see plate 1).

Improvement of the existing navigation channel was initially requested by the Port of Grays Harbor in 1965. In July 1976, an interim feasibility report and environmental impact statement recommending widening and deepening of the navigation channel and modifications to the Union Pacific Railroad bridge crossing the Chehalis River at Aberdeen were submitted to higher authority by Seattle District, Corps of Engineers. Although higher authority and the Office of Management and Budget agreed that the recommended improvements were justified, Seattle District was requested to conduct additional economic, engineering, and environmental studies and to resubmit the report to Congress for construction authorization. This interim feasibility report/ environmental impact statement reflects information resulting from additional studies conducted by Seattle District over the period 1979-1982.

Deep-draft vessels of the world are increasing in size to meet the market needs of lower transportation costs and fuel efficient vessels. Some of the vessels now transporting forest products in worldwide trade cannot call while many others cannot fully load at Grays Harbor because the present 30-foot-deep navigation channel is too shallow and the horizontal clearance of the Union Pacific Railroad bridge at Aberdeen is too narrow. Current world-class forest products vessels have drafts up to 37 feet and beams in excess of 100 feet. The current 30-foot-deep channel limits these vessels to high-cost partial loads at Grays Harbor or to bypassing Grays Harbor entirely.

During the study of navigation needs and problems, a number of possible solutions were considered, including no action, lightering, waterfront renewal, development of other Grays Harbor sites, development of other west coast ports, and improvements to the existing navigation channel. Alternatives considered in detail were no action and improvement of the existing Grays Harbor Federal navigation channel. Technical studies and agency and public input indicate that the public interest would best be served by a navigation improvement plan involving enlargement of the existing deep-draft ship channel at Grays Harbor and replacement of the Union Pacific Railroad bridge. The recommended plan includes the following:

- Widening and deepening the Outer Bar reach from the existing designated 600 feet wide by 30 feet deep channel to a 1,000 feet wide by 46 feet deep channel.

o Widening and deepening the Entrance reach from the existing designated 350 feet wide by 30 feet deep channel to a tapered channel from 1,000 to 600 feet wide and 46 to 38 feet deep.

o Widening and deepening the South and Crossover reaches from the existing designated 350 feet wide by 30 feet deep channels to channels 400 feet wide by 38 feet deep.

o Deepening Moon Island, Hoquiam, and Cow Point reaches from the existing designated channel depth of 30 feet to a channel depth of 38 feet.

o Widening and deepening Aberdeen and South Aberdeen reaches from the existing designated 200 feet wide by 30 feet deep channels to channels 250 feet wide by 36 feet deep.

o Replacing the Union Pacific Railroad bridge over the Chehalis River at Aberdeen to provide a minimum channel horizontal clearance of 250 feet.

o Providing a fendering system for the piers of State Highway 101 bridge located about 200 feet upstream of the Union Pacific Railroad bridge.

o Constructing a turning basin 750 feet wide by 750 feet long by 30 feet deep in Hoquiam reach.

o Widening and deepening the existing widened channel at Cow Point[1/] into a turning basin 1,000 feet wide by 1,000 feet long with a designated depth of 38 feet.

o Constructing a turning basin 750 feet wide by 750 feet long by 30 feet deep near the mouth of Elliott Slough.

o Disposal of dredged material at inner harbor deepwater sites located at Point Chehalis and near the South Jetty and in the ocean about 3-1/2 miles from the harbor entrance.

o Mitigating 4 acres of lost shallow-water fish feeding habitat through development of replacement habitat.

o Mitigating juvenile and adult Dungeness crab mortalities through dredging equipment modifications.

o Improved aids to navigation.

1/Channel widening improvement from the existing 600-foot width to a width of 800 feet was authorized by the Fiscal Year 1982 Energy and Water Development Act (Public Law 97-88, 4 December 1981). Work is expected to be accomplished prior to implementation of channel widening and deepening plan.

The recommended plan would:

o improve safety and reduce potential for vessel-bridge collisions which could disrupt water and overland traffic,

o reduce transportation costs to the benefit of the area and the nation,

o mitigate to the extent feasible for significant adverse environmental impacts, and

o reduce existing hazard of South Jetty being undermined from tidal scouring.

Federal responsibilities include initial and maintenance dredging of the improved navigation channel and placement of additional aids to navigation. The local sponsor, the Port of Grays Harbor, would provide all lands and/or easements required for mitigation of lost shallow-water fish habitat and for aids to navigation and be responsible for maintenance of mitigation lands, if required. The Port of Grays Harbor would also be responsible for insuring that utilities are relocated and port vessel berthing areas are dredged to depths commensurate with the enlarged channel. Replacement of Union Pacific Railroad bridge would be cost shared between the bridge owner and the Federal Government. The State of Washington Department of Transportation would be responsible for fendering the State Highway 101 bridge piers.

In accordance with the requirements set forth in Section 150 of the Water Resources Development Act of 1976 (Public Law 94-587), a determination was made regarding the feasibility of establishing wetland areas by using disposal material. No suitable sites were found for this purpose. The establishment of additional wetlands, as provided for in Section 150, has been and will be studied further under the ongoing Grays Harbor operation and maintenance program and/or during the Continuation of Planning and Engineering (CP&E) phase of the navigation improvement project.

Total first cost of the recommended plan would be $71,300,000 (October 1981 price level). This includes approximately $44,941,000 for channel enlargement, $820,000 for berth dredging by local interests, $23,200,000 for railroad bridge replacement, $669,000 for utility relocations, $810,000 for highway bridge fendering, $550,000 for mitigation measures, and $310,000 for aids to navigation.

The first cost to the Federal Government would be about $68,200,000 with first cost to non-Federal interests being $3,100,000. Total project average annual costs, including average annual maintenance costs, would be $8,080,000 and the average annual benefits would be $14,067,000, resulting in a benefit-to-cost ratio of 1.7 to 1.

Following submittal to the Corps of Engineers' North Pacific Division office, this interim feasibility report/environmental impact statement will be subject to further review by the following entities:

- Corps of Engineers Division office
- Board of Engineers for Rivers and Harbors, Chief of Engineers
- State of Washington and Washington, D.C. level Federal agencies
- Secretary of the Army
- Office of Management and Budget

The report will then be submitted to Congress. If Congress authorizes and funds the project, detailed plans would be prepared and construction undertaken. Although the project schedule presumes beginning the next phase of project planning in Fiscal Year, 1985 CP&E studies could begin in Fiscal Year 1984 should funds be provided by Congress and other budgetary criteria be satisfied. Favorable congressional action on this report will, pursuant to Section 404(r) of the Clean Water Act, exempt that portion of the project involving the relocated Point Chehalis and South Jetty disposal sites from further consideration under Sections 301, 402 and 404 of the Act but not Section 307, effluent standards or prohibitions.

GRAYS HARBOR NAVIGATION CHANNEL IMPROVEMENTS

TABLE OF CONTENTS

TABLE OF CONTENTS (con.)

TABLE OF CONTENTS (con.)

TABLE OF CONTENTS (con.)

ENVIRONMENTAL IMPACT STATEMENT

PLATES
(Bound Behind Environmental Impact Statement)

APPENDIXES
(Bound Behind Plates)

SECTION 1. BACKGROUND

1.01 Study Authority. This interim report is submitted in partial response to resolutions of the Committee on Public Works of the U.S. Senate adopted 21 October and 30 December 1957. These resolutions authorized studies of Grays Harbor and the Chehalis and Hoquiam Rivers, Washington, for navigation improvements, erosion protection, and additional small boat facilities. The text of these resolutions follows:

> "RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby requested to review the report on Hoquiam River, Washington, submitted in House Document Numbered 268, Sixty-second Congress, Second Session, with a view to determining whether it is advisable to modify the existing project in any way at the present time, with particular reference to improvement of facilities for fishing craft based in the area.

> "RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby, requested to review the reports of the Chief of Engineers on Grays Harbor and Chehalis River, Washington, published as House Document Numbered 635, Eightieth Congress, Second Session, and other reports, with a view to determining whether it is advisable to modify the existing project in any way at the present time."

1.02 Type of Study. This report presents the results of a feasibility study undertaken by the Seattle District, U.S. Army Corps of Engineers, in response to the above resolutions, for the purpose of reporting to Congress for their action on the need for, and feasibility of, widening and deepening the existing Federal deep-draft navigation channel from the Pacific Ocean, through Grays Harbor, to Cosmopolis, Washington.

1.03 Description of the Study Area. Grays Harbor is located at the mouth of the Chehalis River on the Washington coast, about 45 miles north of the mouth of the Columbia River and 110 miles south of the entrance to the Strait of Juan de Fuca (see figure 1-1). The harbor is 15 miles long and 11 miles wide. The surface area ranges from 90 square miles at mean higher high water (MHHW) to 38 square miles at mean lower low water (MLLW). The harbor broadens gradually from the river channel at Aberdeen to a large, pear-shaped, shallow estuary encompassing North and South Bays (see figure 1-2). On the oceanside, the estuary is enclosed by two long spits, Point Brown on the north and Point Chehalis on the south. Two convergent dumped-rock jetties, North Jetty and South Jetty, extend seaward from the points of the spits, constricting the harbor entrance width to about 1-1/4 miles.

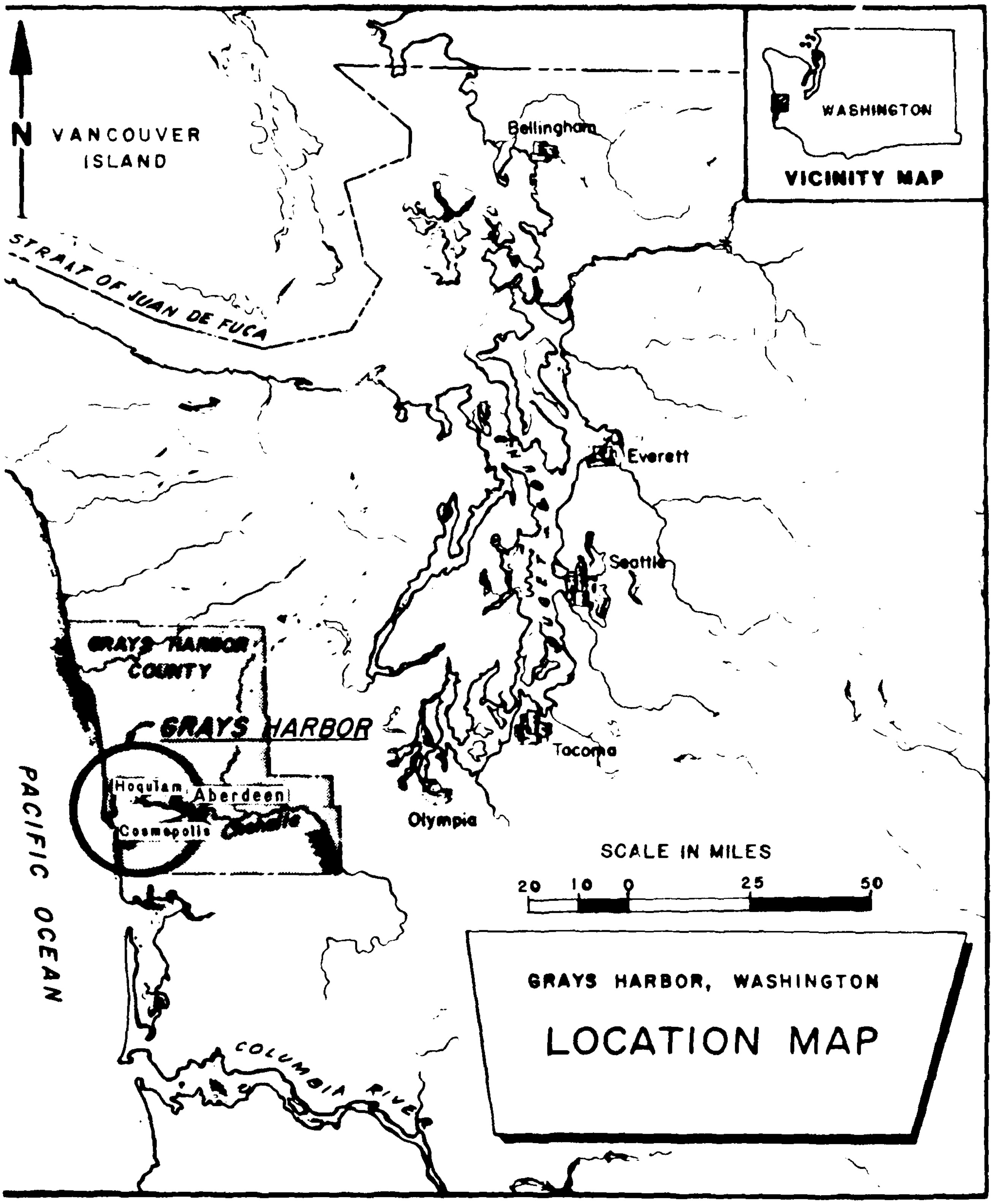

N
VANCOUVER ISLAND
STRAIT OF JUAN DE FUCA
WASHINGTON
VICINITY MAP
Bellingham
Everett
Seattle
Tacoma
Olympia
GRAYS HARBOR COUNTY
GRAYS HARBOR
Hoquiam
Aberdeen
Cosmopolis
Chehalis
PACIFIC OCEAN
COLUMBIA RIVER
SCALE IN MILES
20 10 0 25 50
GRAYS HARBOR, WASHINGTON
LOCATION MAP

FIGURE I – I

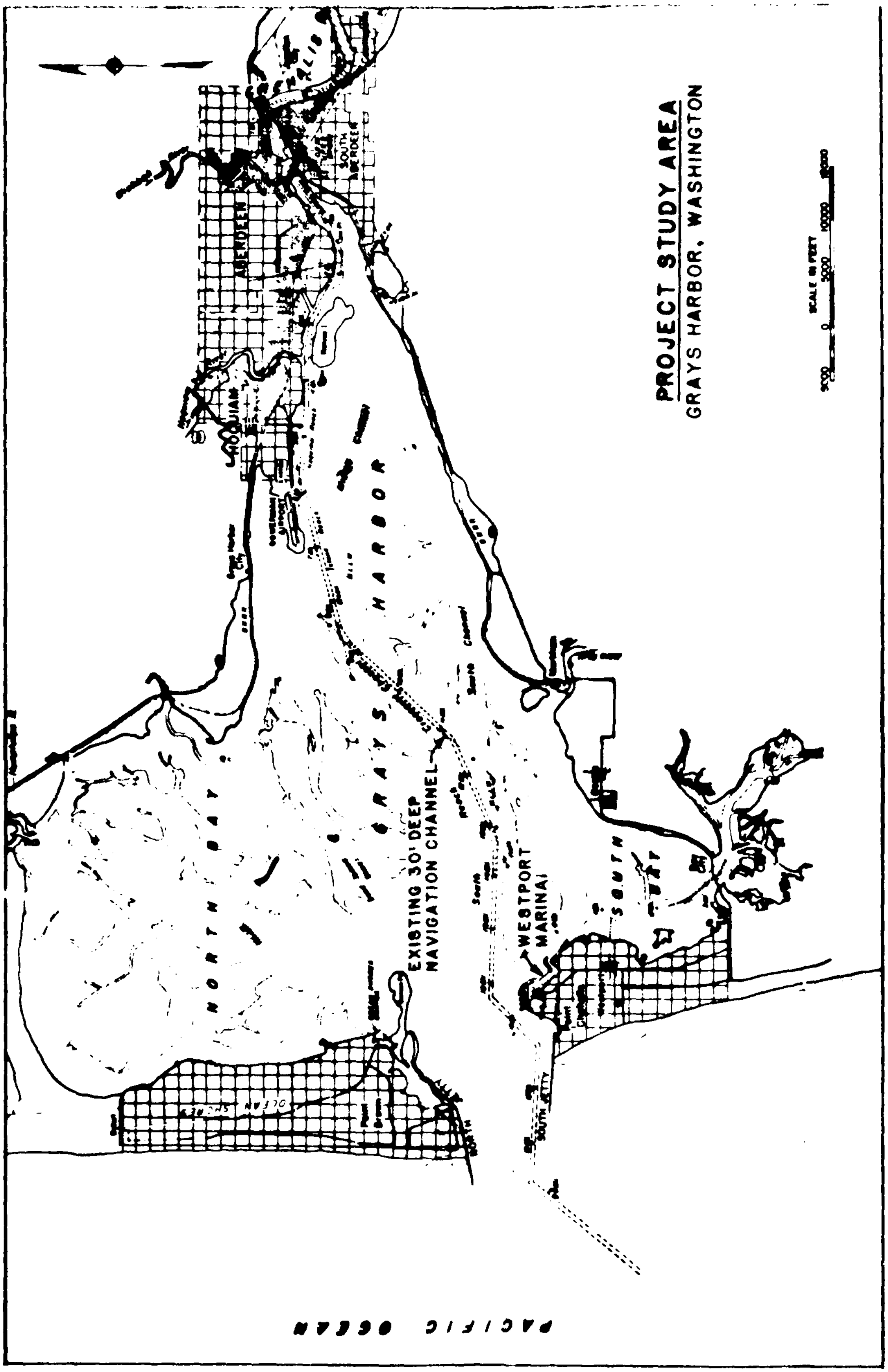

PROJECT STUDY AREA
GRAYS HARBOR, WASHINGTON
SCALE IN FEET
5000 0 5000 10000 15000
ABERDEEN
SOUTH ABERDEEN
HOQUIAM
NORTH BAY
GRAYS HARBOR
EXISTING 30' DEEP NAVIGATION CHANNEL
WESTPORT MARINA
SOUTH BAY
SOUTH JETTY
PACIFIC OCEAN

FIGURE 1-2

1.04 Grays Harbor is located entirely within Grays Harbor County (see figure 1-1). Slightly more than half the county's population of approximately 66,300 (1980 census) resides in the industrialized area at the upper end of the Grays Harbor estuary, which includes the two largest cities, Aberdeen and Hoquiam, and the town of Cosmopolis. The economic development of Grays Harbor County has been historically tied to the region's timber resources, and the economic base of the cities has been their position as manufacturing and rail-water centers for shipping forest products to domestic and international markets. Next in importance are the diversified seafood and cranberry processing industries, together with a substantial tourist industry based on recreation beaches, and sport fishing activities centered at the cities of Westport and Ocean Shores. The area also has extensive ship supply services, small boat building and repair, and related services. Terminals and industrial facilities located in Grays Harbor and along the Chehalis River are identified on plate 2.

1.05 In 1980 the Port of Grays Harbor moved approximately 3.2 million short tons in waterborne commerce. Included were 3.0 million tons of logs and lumber, 166,000 tons of wood chips, 13,000 tons of general cargo, and 55,000 tons of petroleum products. Over the 1976-1980 period, total annual tonnage moving through the port averaged nearly 3.4 million tons compared to an average of approximately 2.9 million tons during 1970-1975. This significant growth in port tonnage primarily reflects a strong general uptrend in export loadings of logs and lumber over the last decade. Future growth of waterborne commerce moving through the port will depend on a variety of factors, including world demand, improvements to the navigation channel, adequate industrial land, and diversification of the export base.

1.06 Existing Navigation Channel. Initial authorization of the existing Federal navigation project was provided in 1896. The navigation channel, which was modified and realined in 1955 and 1977, respectively, is currently 600 feet wide by 30 feet deep over the outer bar, 350 feet wide by 30 feet deep from the entrance channel to Cow Point, and 200 feet wide by 30 feet deep from Cow Point upstream to Cosmopolis. Federal maintenance dredging presently averages about 1.25 million cubic yards (c.y.) annually.

1.07 Needs. The Port of Grays Harbor has asked the Corps of Engineers to study the feasibility of widening and deepening the present navigation channel because the present 30-foot-deep channel is too shallow and the horizontal clearance of the Union Pacific Railroad (UPRR) bridge at Aberdeen is too narrow to handle the increased size ships carrying forest product exports. This request was initially made by Port of Grays Harbor letter dated 9 July 1965 (appendix B). Current world-class, forest-products vessels ship commodities at the least cost per ton. These vessels have drafts up to 37 feet and beams in excess of 100 feet. The current 30-foot channel depth limits these vessels to high-cost partial loads at Grays Harbor or to bypassing Grays Harbor entirely. Furthermore, the number of vessels with allowable drafts

exceeding 30 feet is steadily increasing. In 1975, for example, 33 percent of the vessels departing Grays Harbor had drafts of more than 30 feet and by 1980 this percentage had risen to 62 percent (see figure 1-3). Accordingly, these vessels are partially loaded, resulting in greater unit transportation costs. Navigation channel improvements and bridge modifications would provide safe navigation and allow more cost-efficient movement of waterborne commerce by allowing use of vessels with greater drafts and cargo capacity.

1.08 Previous Studies. Previous Corps of Engineers studies relating to development of navigation, erosion control, and small boat facilities in Grays Harbor are listed in table 1-1. Studies for deep-draft navigation improvements in Grays Harbor were started in November 1966. An interim feasibility report and environmental impact statement (EIS) recommending widening and deepening the navigation channel from the outer bar to Cosmopolis, including modifications to the UPRR bridge over the Chehalis River at Aberdeen, were submitted to higher authority by the Seattle District, Corps of Engineers, in July 1976. Although higher authority and the Office of Management and Budget (OMB) agreed that the recommended improvements were justified, Seattle District was requested to conduct additional studies to resolve concerns relating to the economic evaluation, design criteria, and environmental impacts of the project and resubmit the report to Congress for construction authorization. Additional engineering, economic, and environmental studies conducted in 1979-1982 in response to higher authority and OMB concerns have resulted in some modification to the plan recommended in the 1976 report.

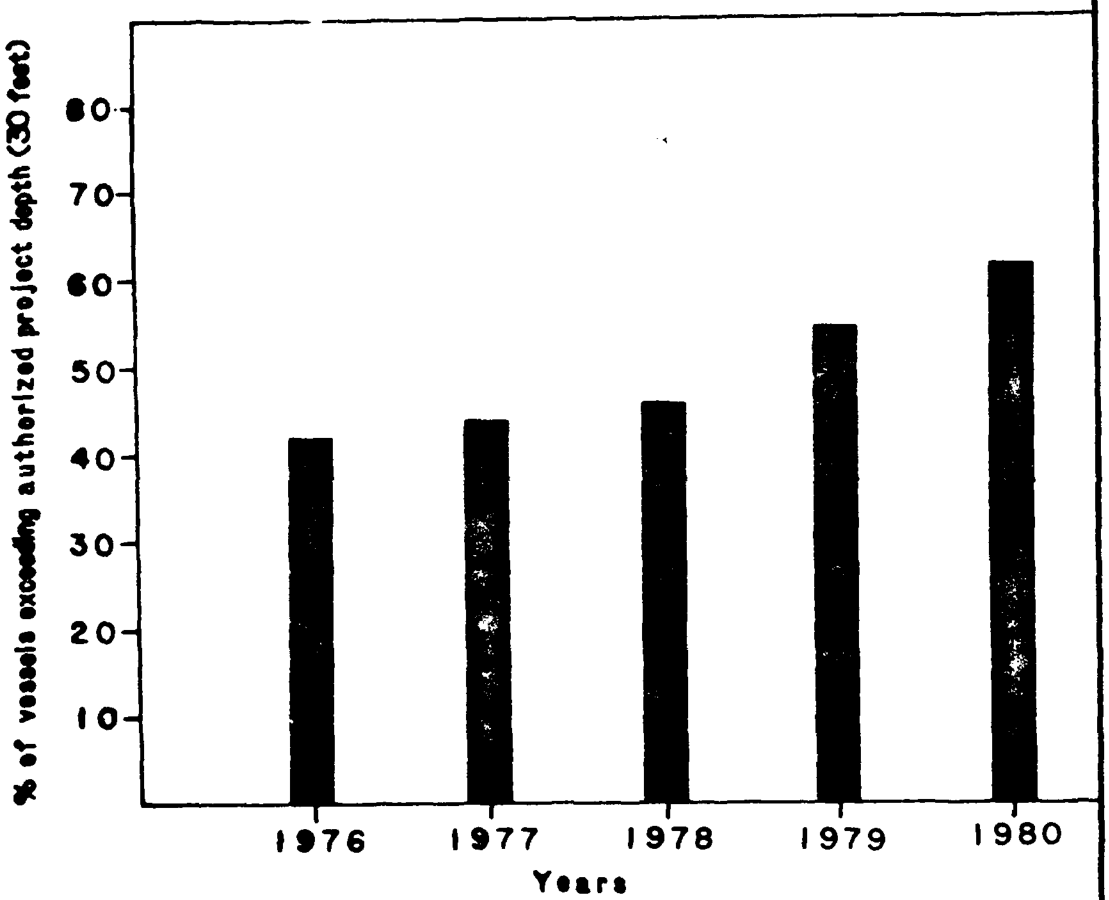
1.09 Pertinent References.

o Grays Harbor and Chehalis River and Hoquiam River, Washington, Interim Feasibility Report, U.S. Army Corps of Engineers, Seattle District, July 1976. This report presents the channel improvements and bridge modification plan recommended in 1976.

o Revised Draft Environmental Impact Statement, Grays Harbor Widening and Deepening, Office of the Chief of Engineers, September 1976. This document assesses the environmental impacts of the channel improvements and bridge modification plan recommended in 1976.

o Final Environmental Impact Statement Supplement No. 2, Long-Range Maintenance Dredging Program, Grays Harbor and Chehalis River Navigation Project, Operation and Maintenance, U.S. Army Corps of Engineers, Seattle District, October 1980. This document assesses the environmental acceptability of continuing Federal maintenance of the existing Grays Harbor navigation project in accordance with the Long-Range Maintenance Dredging Program developed by several Federal, state, and local agencies in 1976.

Percent of Vessels Exceeding Project Depth by Year



Source: Port of Grays Harbor
1980 Annual Report.

TABLE 1-1

PREVIOUS STUDIES

Document Type	No.	Congress	Session	Date	Feature	Recommendation
Executive Document	112	47	1	20 Feb 1882	Exam. & Survey Report	System of slack-water navigation
House Document	576	58	2	2 Mar 1904	Additional Improvement at Grays Harbor	Not approved
House Document	507	59	1	12 Feb 1906	Improvement Inner Grays Harbor & Improve River Channel to Montesano	Approved
House Document	1125	60	2	9 Dec 1908	Improvement of Chehalis River Channel to Montesano	Approved
House of Representatives Committee	29	61	2	4 Mar 1910	Re-examine Reports on Harbor & Bar Entrance	Extend North Jetty
House Document	268	62	2	11 Dec 1911	Hoquiam River Channel Improvement	Approved
House Document	1729	64	2	13 Dec 1913	Improvement of Bar Depth to 24 Feet & Extending South Jetty & Constructing North Jetty	Approved
House Document	582	69	2	14 Dec 1926	Improvement of Harbor	Approved - modifications existing project
House Document	315	70	1	21 May 1928	Improvement of Chehalis River Channel to Montesano	Limited approval
House Document	53	73	1	18 Nov 1932	Prelim. Exam. & Survey of Grays Harbor and Chehalis River	Existing projects be regrouped

TABLE 1-1 (con.)

Document Type	No.	Congress	Session	Date	Feature	Recommendation
House of Representatives Committee	2	74	1	17 Jul 1934	Reconstructing & Extending North & South Jetties	Restore South Jetty & extend 1 mile
House Document	494	78	2	13 Mar 1944	Prelim. Exam. & Survey - Flood Control & Harbor Improvement	Defer studies
House Document	635	80	2	5 May 1948	Improvements at Bay City, Westport, & Hoquiam	Approved
House Document	412	83	2	3 Jun 1954	Extension 30-foot Channel from Terminal No. [illegible] to Cosmopolis	Approved
House Document	30	84	1	22 Oct 1954	Extension of Westhaven Breakwater	Approved
Corps of Engineers				30 Jun 1964	S. Jetty Rehabilitation	Favorable sta. 110 to sta. 150
Committee on Tidal Hydraulics, U.S. Army				Jun 1967	Report on Tidal Hydraulic Aspects of Grays Harbor	Construct hydraulic model, etc.
Letter Report				Jun 1974	South Jetty Rehabilitation and Channel Relocation	Negative
Design Memorandum				Aug 1974	North Jetty Rehabilitation from Sta. 100+00 to Sta. 160+00	Approved
General Design Memorandum				Mar 1976	Relocation of South Reach Navigation Channel	Approved
Detailed Project Report				Nov 1978	Expansion of Westhaven Cove (Westport Marina) Small Boat Basin	Approved
House Resolution	4144	97	1	27 Jul 1981	Improvement of Cow Point Turning Basin Width From 600 Feet to [illegible]00 Feet	Approved

o Grays Harbor Estuary Management Plan, Grays Harbor, Washington, Grays Harbor Regional Planning Commission, Wilsey & Ham, April 1982. The Grays Harbor Regional Planning Commission formed an Estuary Planning Task Force in late 1975 to produce a Grays Harbor Estuary Management Plan (GHEMP). The plan specifies goals, policies and guidelines which strike a balance between the necessary and appropriate development of the harbor and protection and preservation of the estuary's natural resources. The plan does not eliminate or modify any of the laws, regulations, or policies which govern the actions and decisions of local, state or federal agencies, but rather improves their interpretation, interaction and implementation.

o Final Environmental Impact Statement, Weyerhaeuser Export Facility at DuPont, U.S. Army Corps of Engineers, Seattle District, April 1982. Grays Harbor is identified as a potential export facility site but not selected by Weyerhaeuser for development primarily because of insufficient acreage and channel depths. No significant change in current Weyerhaeuser operations at Grays Harbor is expected to occur as a result of development at DuPont.

o Western Coal Exports to the Pacific Basin, Western Governors Policy Office, Denver, Colorado, February 1982. A five-volume report dealing with demand, supply, overland transportation, port and marine facilities, and institutional/regulatory issues surrounding export of large volumes of coal to the Pacific Rim. Grays Harbor is identified as a possible transshipment point; however, current navigation draft is inadequate to handle the larger cost-effecient vessels.

o Feasibility of a Diversified Bulk Commodities Terminal at Existing Terminal No. 2 - Port of Grays Harbor, Swan Wooster Engineers, Portland, Oregon, February 1982. A study recommending the conversion of an existing log/lumber terminal into a diversified bulk commodities terminal handling principally wood chips, bentonite, sulfur, talc, and spot shipments of coal.

o Coal/Grain - A Technical Feasibility Study for an Export Terminal at the Port of Grays Harbor, ABAM Engineers, Federal Way, Washington, and ORBA Corporation, Fairfield, New Jersey, November 1981. A study finding that it is feasible to construct a facility to handle up to 10 million tons of coal and 3 million tons of grain annually from an existing industrial site on Grays Harbor. Shipping draft limitations are the single greatest constraint.

o 1980 Port System Study for the Public Ports of Washington State, CH2M-Hill, Bellevue, Washington, December 1980. A study which concludes that coal exports will begin and grow to 26 million tons annually by the year 2000, and that some percentage could be shipped from Grays Harbor provided channel depth was increased to handle coal vessels.

o Onshore Support Activities Planning Study for Outer Continental Shelf (OCS) Construction, ABAM Engineers, Tacoma, Washington, October 1978. A study concluding that Grays Harbor has very evident potential for supporting OCS development through construction of offshore oil production platforms, component for ENG terminals, modules for oil and gas production, and components for pipelines, all to be shipped by water from one of several possible sites on Grays Harbor.

o Regional Water Supply Study for the Grays Harbor Area, Battelle-Northwest, Richland, Washington, April 1967. A study which examines alternative supplies of industrial water, projected uses, and constraints. The most critical constraint identified is the lack of deep draft for water transportation of wood products, primary metals, chemicals, and petroleum.

1.10 Other pertinent references relating to the socioeconomic, engineering, design, and environmental aspects of the study are listed in the EIS and appropriate appendixes of this report.

SECTION 2. PLANNING OBJECTIVES

2.01 Planning Objective. The planning objective for this study was to improve the efficiency and safety of deep-draft water transportation in Grays Harbor.

2.02 Planning Criteria.

a. General. In formulating plans to meet the planning objective, a wide range of planning criteria were considered. These criteria were used in screening and evaluating alternative plans and in measuring each plan's contribution to the National Economic Development (NED), Environmental Quality (EQ), Regional Development (RD), and Other Social Effects (OSE) accounts of the Water Resources Council's Principles and Standards. This comparative evaluation of alternative plans is presented in section 3. The criteria considered include legal, financial, policy, social, economic, and environmental factors and conditions which impose constraints and limitations on the planning process or provide rules and guidelines for evaluation of the plans. The criteria also include needs, opportunities, and concerns, in addition to the primary planning objective, that were identified during the planning process. Not all the criteria are compatible and no plan could fully satisfy all of them. All applicable planning criteria for the study are presented in the following paragraphs under the account to which they are primarily related.

b. National Economic Development Criteria. The NED criteria consist of needs addressed by the alternative plans that result in NED benefits and the constraints that are applied to the calculation of these benefits. The pertinent NED criteria are as follows:

o Allow economies of scale cost savings through ability to more fully utilize larger, more cost effective deep-draft vessels.

o Improve safety and reduce risk of vessel groundings.

o Reduce potential for vessel-bridge collisions (and possible subsequent disruption of overland or waterborne traffic patterns).

o Develop annual benefits which exceed annual costs.

o Use current Federal discount rate in plan economic analysis in determining annual costs and in discounting future benefits (7-5/8 percent) and current prices and conditions in valuing future benefits (October 1981 prices).

o Use 50-year project economic life in plan economic analysis.

o Insure that each separable unit or purpose of a plan is economically justified.

o Include in average annual cost estimates interest and amortization of construction costs, if any, and provision for annual maintenance, operation, and major replacement.

o Measure economic efficiency of alternative plans by net benefits with the most efficient plan being that which maximizes net benefits.

o Include in each plan all actions necessary to realize its economic benefits.

o Insure that plans are implementable within a range of economic conditions.

c. Environmental Quality Criteria. The EQ criteria which follow consist of specific environmental resources-related constraints and opportunities. These include criteria imposed by Federal, state, and local regulations and those uniquely related to the Grays Harbor area. The environmental resources of the area are described in section 3 of the draft EIS. Pertinent EQ criteria are as follows:

o Maintain the natural and beneficial values of the undeveloped portions of the flood plain in the study area in compliance with Executive Order (EO) 11988.

o Maintain wetland acreage in the study area in conformance with Section 404 of the Clean Water Act, EO 11990, and other pertinent laws and regulations.

o Maintain and/or enhance important or critical fish and wildlife habitats in the study area, including intertidal and shallow subtidal areas, riparian zone and overstory, and wetland vegetation.

o Minimize Dungeness crab entrainment by dredging operations.

o Maintain or salvage significant (as determined by National Register of Historic Places criteria) historic and prehistoric cultural resources sites affected by potential project construction or effects in accordance with the authorities contained in existing legislation and EO's, including the National Historic Preservation Act of 1966; the Reservoir Salvage Act of 1960, as amended by Public Law 93-291; and EO 11593.

o Comply with the State of Washington Coastal Zone Management Programs for the Grays Harbor area, to the maximum extent practicable. This includes the Grays Harbor Estuary Management Plan when that plan has been adopted by amendments to applicable Coastal Zone Management Programs.

o Protect any threatened or endangered species in the study area and their critical habitat.

o Maintain or enhance water quality in the study area in conformance with the Clean Water Act of 1977 (Public Law (PL) 92-500, as amended).

o Maintain water quality and the ecology of the open ocean in conformance with Sections 102 and 103 of PL 92-532, Marine Protection, Research and Sanctuaries Act of 1972.

o Avoid decreasing existing air quality in the study area.

d. Regional Development Criteria. The RD criteria which follow consist of opportunities related to increased economic efficiency within the Grays Harbor study area that do not necessarily provide increases in NED. This list also includes areas of concern listed in Section 122 of PL 91-611. Pertinent RD criteria relating to the region of Grays Harbor County and adjacent counties are as follows:

o Increase employment.

o Increase net income to businesses.

o Increase property values.

o Increase per capita real income.

o Increase tax revenues.

e. Other Social Effects Criteria. The OSE criteria listed below include those engineering policy standards that are applied to all alternatives to assure the maintenance of public health and safety and those opportunities and constraints related to the social well-being of people. This list also includes areas of concern listed in Section 122 of PL 91-611. Pertinent OSE criteria are as follows:

o Avoid the relocation of residential properties.

o Avoid the relocation of public facilities and properties and the resulting inconvenience to residents during construction.

SECTION 3. FORMULATION AND EVALUATION OF ALTERNATIVES

3.01 Plan Formulation Approach. The plan formulation process began with the identification of the planning objective and the planning criteria. A wide range of structural and nonstructural alternatives were then identified to address the planning objective while considering the planning criteria. Each alternative's contribution to the NED, EQ, RD, and OSE accounts of the Water Resources Council's Principles and Standards was then evaluated. The planning criteria formed the basis of comparison of the plans and measurement of their contribution to the four accounts. Alternatives were screened, evaluated, and refined as the result of technical studies and an extensive coordination program. The final alternatives were again thoroughly evaluated against the planning criteria, and a detailed system of accounts was developed to measure their contribution to the NED, EQ, RD, and OSE accounts. Based on the results of this analysis, an alternative that results in maximum net positive economic return (NED Plan) and an alternative that is least damaging to the environment (LED Plan) were designated. The most effective combination of plans which best met the planning objective and criteria was selected as the recommended plan.

3.02 Preliminary Analysis and Screening of Alternatives. Conceptual alternatives considered during preliminary planning were as follows:

- No action.
- Lightering (i.e., transferring cargo between anchored vessels and the shore by barge or smaller, shallow-draft vessels).
- Waterfront renewal (i.e., rehabilitation of deteriorated dock facilities).
- Development of other Grays Harbor sites.
- Development of other west coast ports.
- Channel improvements.

3.03 The no-action alternative was carried into the final analysis. Other alternatives considered during preliminary planning leading to the 1976 feasibility report but eliminated because they were not fully responsive to the planning objective include the following:

- Lightering: eliminated from consideration because (1) harsh wave climate in outer harbor anchorages precludes lightering, (2) the modern sorting and loading facilities owned by the Port of Grays Harbor and private shippers of the area could not be effectively used, and (3) the double handling of cargo and additional costs of shallow-draft lightering vessels would increase the cost of waterborne commerce in the harbor.

o Waterfront renewal: eliminated from consideration because (1) many of the dock facilities in the harbor and along the Chehalis River are new or recently rehabilitated with many useful years remaining and (2) channel improvements would still be required to accommodate world-class forest products vessels.

o Development of other Grays Harbor sites: eliminated from consideration because new harbor site development in lieu of using existing facilities would be environmentally unacceptable and economically impractical.

o Development of other west coast ports: development of four existing ports (Willapa, Olympia, Tacoma, and Longview) and one planned port (Weyerhaeuser's DuPont facility) was eliminated from consideration for major activity because excessive overland transportation costs would be associated with transferring Grays Harbor forest products to any of these sites (see figure 3-1 for site locations). See appendix C for an update for the economics of this alternative.

As the 1976 feasibility report contains a full discussion of the preliminary alternatives, they have been only briefly treated here.

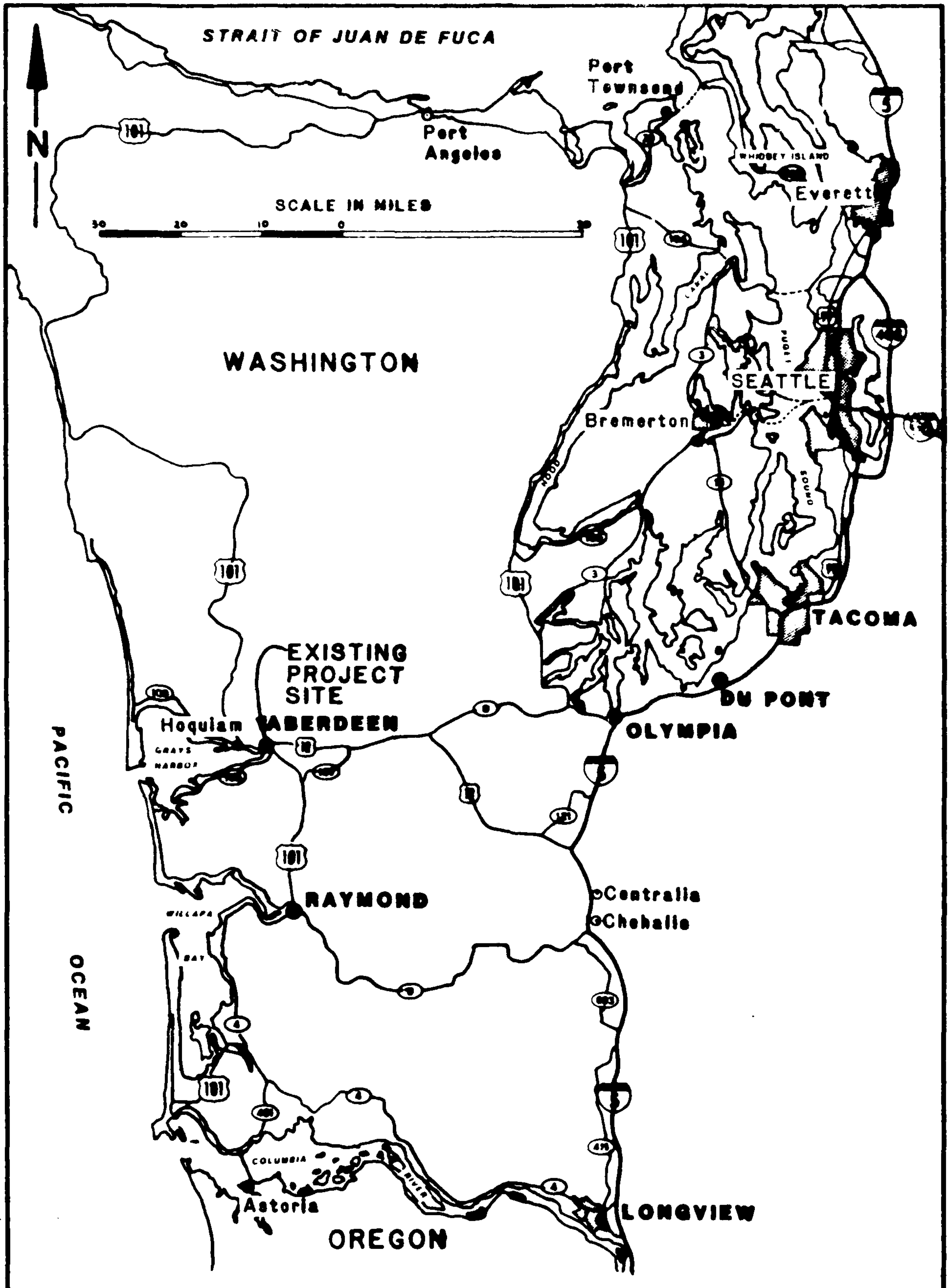
3.04 The channel improvement alternative was carried into final analysis. Variations on the channel improvement alternative were considered. These included three plans, which differ primarily by location of dredged material disposal, dredging methods, and dredging schedule.

3.05 Table 3-1 at the end of this section displays project dimensions for the no-action alternative (alternative 1) and the three channel improvement plans (alternatives 2a-2c). Table 3-2 presents features of the channel improvement plans. A system of accounts comparing the no-action alternative with the channel improvement plans is presented in table 3-3.

3.06 Alternative 1, No Action.

a. Description. Under this alternative, the existing Federal navigation channel (see plate 1) would be maintained at the present authorized depth of 30 feet (MLLW). Ships requiring more than 30 feet of draft would continue to rely on tides, and drafts would be limited to a maximum of 33-34 feet. An additional restriction on the bar might occur in the future that would further limit vessel sizes. The present bar controlling depth is 38 feet, and if shoaling would occur up to the authorized depth of 30 feet, vessel drafts would be limited to about 25 feet. Because of draft restrictions, larger ships would be forced to sail with partial loads or to bypass Grays Harbor. Over the last several years, the percent of voyages exceeding the 30-foot project depth at Grays Harbor has increased steadily (see figure 1-3). This trend is expected to continue because worldwide, older, generally smaller ships are being replaced with new, generally larger ships. As the world fleet

CORPS OF ENGINEERS U. S. ARMY



ALTERNATIVE PORT LOCATIONS

continues to increase in size (length, beam, and draft), a larger percentage of vessels leaving Grays Harbor may be forced to (a) wait for favorable tides, (b) depart with less than a full load, or (c) bypass Grays Harbor except for one or two calls per year. Vessels will not be used efficiently and higher shipping costs will result. As can be seen from the following evaluation, this alternative is not responsive to the planning objective.

b. Evaluation With Key Criteria.

(1) National Economic Development Criteria.

o Transportation costs would not be reduced.

o Safety concerns would remain due to the constriction at the UPRR bridge.

(2) Environmental Quality Criteria.

o Undeveloped portions of the flood plain would not be affected.

o Wetlands would not be affected.

o Intertidal and shallow subtidal habitats would not be affected.

o Existing maintenance dredging would continue to reduce the number of adult Dungeness crabs harvested by the crab fishery at Westport (500,000-3,000,000 crabs/year) by an estimated 0.84 percent each year.

o No significant cultural resource sites would be affected.

o State coastal zone management and local shoreline management programs would be complied with.

o No threatened or endangered species or habitat would be affected.

o Water quality in the study area would be maintained.

o Water quality and ecology of the open ocean would be maintained.

o Air quality in the study area would not change significantly.

(3) Regional Development Criteria.

o Employment in Grays Harbor and adjacent counties would not increase at same rate as with the navigation improvement project and might decrease.

o Income to businesses in Grays Harbor and adjacent counties would not increase and might decrease.

o Property values would not increase and might decrease.

o Per capita real income would not increase and might decrease.

o Tax revenues would not increase and might decrease.

(4) Other Social Effects Criteria.

o No residential properties would be relocated.

o No public facilities would be relocated.

3.07 Alternative 2a, Channel Widening and Deepening, All Material Disposed Either at Inner Harbor Sites or About 2-1/2 Miles From Harbor Mouth (NED Plan).

a. Description. Under this alternative, the authorized Federal channel would be widened and deepened to dimensions shown in tables 3-1 and 3-2. Hopper and clamshell dredges would be used with material disposed of in deep water off Point Chehalis and the South Jetty and in the open ocean approximately 2-1/2 miles to sea.1/ Any material unacceptable for open-water disposal would be disposed of at a confined upland disposal site. Plates 3 and 7 show the dredged material disposal site locations assumed for purposes of the feasibility study. Hydraulic data indicates that scour action at the relocated Point Chehalis disposal sites and the South Jetty site (see plate 3 for location) limits their combined disposal volume to approximately 4 million c.y. per year. These sites have the advantages of being the closest to the source of the material and because of their semiprotected location they can be

1/For purposes of the feasibility report, the project-related costs of ocean disposal have been estimated for ocean disposal sites located near the entrance to Grays Harbor about 2-1/2, 3-1/2, and 8 miles west of the ends of the Grays Harbor North and South Jetties. Biological, physical, and chemical tests would be conducted at several potential ocean disposal sites (including these sites) during the Continuation of Planning and Engineering (CP&E) stage of this project. Resource agencies have agreed that an acceptable site exists within 8 miles from the entrance to Grays Harbor. A final decision on the location of an ocean disposal site or sites would be based on CP&E studies.

utilized at all times of the year by nonoceangoing dredge equipment. Hydraulic and model studies, and past experience, indicate that this disposal material generally will be transported seaward by ebb currents. Accordingly, alternative 2a would utilize these sites to the maximum extent possible both for initial construction and future maintenance work. The remainder of the material, except for about 1 million c.y. from the South Aberdeen reach, would be disposed of approximately 2-1/2 miles to sea. Material from the South Aberdeen reach would be placed at an existing upland log storage site shown on plate 7. Table 3-2 summarizes the equipment type, disposal sites, quantities, and costs for dredging and dredged material disposal. Alternative 2a would produce the largest potential adverse environmental impact because of the potential water quality impacts, the mortality of crabs by the hopper dredges, and the potential of dumped silty material reentering or being recirculated within the estuary, particularly from the relocated Point Chehalis sites. Under alternative 2a, the UPRR swing-span bridge at Aberdeen would be replaced with a vertical lift span providing a 250-foot-horizontal opening perpendicular to the channel and a vertical clearance of 140 feet above MHHW. Placement of additional aids to navigation and a fendering system for the piers of the State Highway 101 bridge located about 200 feet upstream of the UPRR bridge would also be provided under this alternative. Total construction cost for alternative 2a is $66,660,000.

b. Evaluation With Key Criteria.

(1) National Economic Development Criteria.

o Economies of scale cost savings would be realized.

o Safety would be improved and potential for vessel groundings reduced.

o Potential for vessel-bridge collisions would be reduced.

o Based upon 50-year project life and a 7-5/8 percent interest rate, the average annual benefits of $14,067,000 exceed the average annual costs of $7,545,000. The benefit-to-cost ratio of alternative 2a is 1.9 to 1.0.

o Each separable unit of plan provides benefits exceeding costs.

(2) Environmental Quality Criteria.

o Undeveloped portions of the flood plain would not be affected.

o Wetlands in the outer harbor could be affected by recirculation of dredged material.

o Approximately 4 acres of shallow subtidal habitat removed by dredging would be mitigated through creation of replacement habitat.

o Initial project dredging could reduce the number of adult Dungeness crabs harvested by the crab fishery at Westport (500,000-3,000 crabs/year) by an estimated 1.15 to 3.96 percent for each of the 2 years of construction dredging and 2 years following construction. However, this impact would be avoided or mitigated through dredge equipment modification measures as part of the plan.

o Proposed maintenance dredging could increase the long-term impact on the number of adult Dungeness crabs harvested by the crab fishery at Westport from the existing estimate 0.84 percent to 3.19 percent. However, this impact would be avoided or mitigated through dredge equipment modifications.

o No significant cultural resource sites would be affected.

o State coastal zone management and local shoreline management programs would be complied with.

o Threatened or endangered species or their habitat would not be adversely affected.

o Water quality in the study area would be temporarily impacted during project construction. Maintenance of harbor channels would not be significantly different from existing conditions so new water quality impacts due to channel maintenance would be minimal.

o Possible adverse impact to razor clam resource and Dungeness crab fishery resulting from dredged material disposal could result.

o Air quality would be temporarily disturbed during project construction but not permanently affected.

o Possible adverse impact on juvenile salmonids from dredging activity during critical period of downstream migration could result.

(3) Regional Development Criteria.

o Employment in Grays Harbor and adjacent counties may increase.

o Income to businesses in Grays Harbor and adjacent counties would increase.

o Property values would increase.

o Per capita real income may increase.

o Tax revenues would increase.

(4) Other Social Effects Criteria.

o No residential properties would be relocated.

o Minor disruptions could occur during construction of the UPRR bridge and relocation of utilities.

3.08 Alternative 2b, Channel Widening and Deepening, All Material Disposed About 8 Miles From Harbor Mouth (LED Plan).

a. Description. This alternative would involve widening and deepening the existing channel similar to alternative 2a as shown in tables 3-1 and 3-2. Alternative 2b would have reduced environmental impacts because dredged material would likely be disposed of further at sea. Also, clamshell dredges would be used from the inner estuary up to the entrance reach to minimize crab uptake. Any material unacceptable for open-water disposal would be disposed of at a confined upland site. All dredged material suitable for open-water disposal would be disposed of at a site 8 miles to sea. Table 3-2 provides a summary of equipment type, disposal sites, quantities, and costs for dredging and dredge material disposal. Under alternative 2b, the UPRR swing-span bridge would be replaced with a lift span providing a clear channel clearance of 250 feet and a vertical clearance of 140 feet above MHHW. Placement of additional aids to navigation and a fendering system for the State Highway 101 bridge would also be provided. The construction cost for alternative 2b is $95,200,000. With interest during construction of about $11,375,000, a total investment of $106,575,000 would be required for this alternative. Because of the environmental constraints that would be imposed on dredging, a longer period of time would be required to construct the project, thereby resulting in a substantially higher cost than for alterative 2a.

b. Evaluation With Key Criteria.

(1) National Economic Development Criteria.

o Economies of scale cost savings would be realized.

o Safety would be improved and potential for vessel groundings reduced.

o Potential for vessel-bridge collisions would be reduced.

o Based upon 50-year project life and a 7-5/8 percent interest rate, the average annual benefits of $14,067,000 do not exceed the average annual costs of $14,080,000. The benefit-to-cost ratio for alternative 2b is 0.99 to 1.0.

(2) Environmental Quality Criteria.

o Undeveloped portions of the flood plain in the study area would not be affected.

o Wetlands in the study area would not be affected.

o Aproximately 4 acres of shallow subtidal habitat removed by dredging would be mitigated through creation of replacement habitat.

o Initial project dredging could reduce the number of adult Dungeness crabs harvested by the crab fishery at Westport (500,000-3,000,000 crabs/year) by an estimated 0.55 to 1.90 percent for each of the 2 years of construction dredging and for each of the 2 years following construction. However, this impact would be avoided or mitigated through dredge equipment modification measures as part of the plan.

o Proposed maintenance dredging could increase the impact on the number of adult Dungeness crabs harvested by the crab fishery from the existing estimated 0.84 percent to 1.53 percent. However, this impact would be avoided or mitigated through dredge equipment modifications.

o No significant cultural resource sites would be affected.

o State coastal zone management and local shoreline management programs would be complied with.

o Threatened or endangered species or their habitat would not be adversely affected.

o Water quality in the study area would be temporarily impacted during project construction. Maintenance of harbor channels would not be significantly different from existing conditions so new water quality impacts due to channel maintenance would be minimal.

o Air quality would be temporarily disturbed during project construction but not permanently affected.

(3) Regional Development Criteria.

o Employment in Grays Harbor County and adjacent counties may increase.

o Income to businesses in Grays Harbor and adjacent counties would increase.

o Property values would increase.

o Per capita real income may increase.

o Tax revenues would increase.

(4) Other Social Effects Criteria.

o No residential properties would be relocated.

o Minor disruptions could occur during construction of the UPRR bridge and relocation of utilities.

3.09 Alternative 2c, Channel Widening and Deepening, All Material Disposed Either at Inner Harbor Sites or About 3-1/2 Miles From Harbor Mouth (Recommended Plan).

a. Description. The recommended plan combines features of alternatives 2a and 2b. Widening and deepening of the existing channel would be similar to that for alternatives 2a and 2b as shown in tables 3-1 and 3-2. Dredging would be accomplished using both clamshell and hopper dredges. Clamshell dredging would be used in the upper reaches (South Aberdeen-Moon Island) and hopper dredging would be used in the lower reaches (Crossover-Outer Bar). A hopper dredge may be used in the lower half of Moon Island reach to facilitate dredge scheduling. Table 3-2 summarizes equipment type, disposal sites, quantities, and costs for dredging and dredged material disposal. Dredged material would be predominantly disposed of at the relocated Point Chehalis sites and at the South Jetty site; however, material from the Hoquiam, Cow Point, and Aberdeen reaches, primarily silty in nature, which may be unacceptable for disposal within the harbor, would be disposed of 3-1/2 miles to sea. Dredging schedules would be modified to lessen the impact on crabs and reduce impacts on juvenile salmonids. The UPRR swing-span bridge at Aberdeen would be replaced with a lift span to increase the horizontal channel clearance from 125 feet to 250 feet. Under this alternative additional aids to navigation and a fendering system for the State Highway 101 bridge would also be provided. Estimated total construction cost for alternative 2c is $71,300,000.

b. Evaluation With Key Criteria.

(1) National Economic Development Criteria.

o Economies of scale cost savings would be realized.

o Safety would be improved and potential for vessel groundings reduced.

o Potential for vessel-bridge collisions would be reduced.

o Based upon 50-year project life and a 7-5/8 percent interest rate, the average annual benefits of $14,067,000 exceed the average annual costs of $8,080,000, including first cost of construction, annual maintenance, operation, and major replacement. The benefit-to-cost ratio of alternative 2c is 1.7 to 1.0.

o Each separable unit of the plan provides benefits exceeding costs.

(2) Environmental Quality (EQ) Criteria.

o Undeveloped portions of the flood plain would not be affected.

o Wetlands in the study area would not be affected.

o Approximately 4 acres of shallow subtidal habitats removed by dredging would be mitigated through creation of replacement habitat.

o Initial project dredging could reduce the number of adult Dungeness crabs harvested by the crab fishery at Westport (500,000-3,000,000 crabs/year) by an estimated 0.92 to 3.17 percent for each of the 2 years of construction dredging and for each of the 2 years following construction. However, this impact would be avoided or mitigated through dredge equipment modification measures as part of the plan.

o Proposed maintenance dredging would increase the impact on the number of adult Dungeness crabs harvested by the crab fishery from the existing estimated 0.84 percent to approximately 2.6 percent. However, this impact would be avoided or mitigated through dredge equipment modifications.

o No significant cultural resource sites would be affected.

o State coastal zone management and local shoreline management programs would be complied with.

o Threatened or endangered species or their habitat would not be aversely affected.

o Water quality in the study area would be temporarily impacted during project construction. Maintenance of harbor channels would not be significantly different from existing conditions so new water quality impacts due to channel maintenance would be minimal.

o Air quality would be temporarily disturbed during project construction. Any future impacts on air quality are expected to be minor.

(3) Regional Development Criteria.

o Employment in Grays Harbor and adjacent counties may increase.

- Income to businesses in Grays Harbor and adjacent counties would increase.

- Property values would increase.

- Per capita real income may increase.

- Tax revenues would increase.

(4) Other Social Effects Criteria.

- No residential properties would be relocated.

- Minor disruptions could occur during construction of the UPRR bridge and relocation of utilities.

TABLE 3-1

PROJECT DIMENSIONS FOR ALTERNATIVE 1 AND ALTERNATIVES 2a-2c

PORTION OF CHANNEL	CHANNEL DIMENSIONS NO ACTION ALTERNATIVE 1	 CHANNEL IMPROVEMENTS ALTERNATIVES 2a-2c
Outer Bar	600 ft. wide 30 ft. deep	1,000 ft. wide 46 ft. deep
Entrance Channel	350 ft. wide 30 ft. deep	1,000 to 600 ft. wide 46-38 ft. deep
South Reach	350 ft. wide 30 ft. deep	400 ft. wide 38 ft. deep
Crossover Reach	350 ft. wide 30 ft. deep	400 ft. wide 38 ft. deep
Moon Island Reach	350 ft. wide 30 ft. deep	350 ft. wide 38 ft. wide
Hoquiam Reach	350 ft. wide 30 ft. deep	350 ft. wide 38 ft. deep
Cow Point Reach	350 ft. wide 30 ft. deep	350 ft. wide 38 ft. deep
Aberdeen Reach	200 ft. wide 30 ft. deep	250 ft. wide 36 ft. deep
South Aberdeen Reach	200 ft. wide 30 ft. deep	250 ft. wide 36 ft. deep
Hoquiam Turning Basin	None	750 ft. by 750 ft. 30 ft. deep
Cow Point Turning Basin	800 ft.1/ by 1,000 ft. 30 ft. deep	1,000 ft. by 1,000 ft. 38 ft. deep

1/Channel widening improvement from 600 feet to 800 feet authorized by Fiscal Year 1982 Energy and Water Development Act (PL 97-88, 4 December 1981). Work is expected to be accomplished prior to implementation of channel widening and deepening plan.

TABLE 3-1 (con.)

PORTION OF CHANNEL	CHANNEL DIMENSIONS NO ACTION ALTERNATIVE 1	 CHANNEL IMPROVEMENTS ALTERNATIVES 2a-2c
Aberdeen Turning Basin (authorized but not maintained)	600 ft. by 1,000 ft. 30 ft. deep	None
Elliott Slough Turning Basin	None	750 ft. by 750 ft. 30 ft. deep
Cosmopolis Turning Basin (authorized but not maintained)	550 ft. by 1,000 ft. 30 ft. deep	None

TABLE 3-2

FEATURES OF ALTERNATIVE CHANNEL IMPROVEMENT PLANS

Project Feature	Alt. 2a NED Plan	Alt. 2b LED Plan	Alt. 2c Recommended Plan	Recommended Plan Principal Rationale
Outer Bar Reach (Harbor mile 22.0 to harbor mile 19.4)				
Authorized Depth1/	46 feet	46 feet	46 feet	Required for adverse wave conditions
Width	1,000 feet	1,000 feet	1,000 feet	Required for adverse wave, currents, and weather conditions
Preferred Construction Period	May-Oct	Jul-Sep	May-Sep	Only time with acceptable wave conditions on bar for ocean disposal and bar dredging
Initial Constr Equipment	Hopper	Hopper	Hopper	Required for adverse wave conditions on bar
Initial Constr.2/ Dredge Material Disposal (1,000's c.y.)	4,0003/ c.y. marine sands to 2-1/2 mile site4/	3,000 c.y. marine sands to ocean 8 miles	4,0003/ c.y. marine sands to 3-1/2-mile site4/	Most economical given constraint of minimizing sediment return. See footnote 4.

1/Proposed Federal authorized channel depth below MLLW. Actual depth at time of dredging would be approximately 4 feet greater due to allowances for advanced maintenance and construction tolerance.

2/Quantities shown include 4 feet of overdepth allowances.

3/Includes 1 million c.y. redredging of material disposed of at the Point Chehalis and South Jetty sites which are assumed to migrate seaward onto the outer bar. Less expensive to redredge than to transport all material to ocean.

4/For purposes of the feasibility report, the project-related costs of ocean disposal have been estimated for ocean disposal sites located near the entrance to Grays Harbor about 2-1/2, 3-1/2 and 8 miles west of the ends of the Grays Harbor North and South Jetties. Biological, physical, and chemical tests would be conducted at several potential ocean disposal sites (including these sites) during the CP&E stage of this project. Resource agencies have agreed that an acceptable site exists within 8 miles from the entrance to Grays Harbor. A final decision on the location of the disposal site or sites would be based on CP&E studies. Ocean disposal is preferred for silty material.

TABLE 3-2 (con.)

Project Feature	Alt. 2a NED Plan	Alt. 2b LED Plan	Alt. 2c Recommended Plan	Recommended Plan Principal Rationale
Outer Bar Reach (Harbor mile 22.0 to harbor mile 19.4) (con.)				
Initial Constr. Cost ($\$10^6$)	4.40	6.60	5.00	
Existing O&M		None required		
New Annual O&M Material Disposal (1,000's c.y.)	800 c.y. sands to ocean 2-1/2 miles	600 c.y. sands to ocean 8 miles	800 c.y. sands to ocean 3-1/2 miles	See footnote 1/.
New O&M Frequency, and Location	1/2 of channel every 1-2 years.			
New Annual O&M Cost Total ($\$10^6$) 2/	.88	1.32	1.0	

1/For purposes of the feasibility report, the project-related costs of ocean disposal have been estimated for ocean disposal sites located near the entrance to Grays Harbor about 2-1/2, 3-1/2 and 8 miles west of the ends of the Grays Harbor North and South Jetties. Biological, physical, and chemical tests would be conducted at several potential ocean disposal sites (including these sites) during the CP&E stage of this project. Resource agencies have agreed that an acceptable site exists within 8 miles from the entrance to Grays Harbor. A final decision on the location of the disposal site or sites would be based on CP&E studies. Ocean disposal is preferred for silty material.

2/Does not include allowances for contingencies and E&D and S&A.

TABLE 3-2 (con.)

Project Feature	Alt. 2a NED Plan	Alt. 2b LED Plan	Alt. 2c Recommended Plan	Recommended Plan Principal Rationale
Entrance Reach (Harbor mile 19.4 to harbor mile 15.4)				
Authorized Depth 1/	46 - 38 feet	46 - 38 feet	46 - 38 feet	Based on economically optimum interior channel depth of 38 feet with allowances for transitions from adverse wave conditions on the bar.
Width	1,000 - 600 feet	1,000 - 600 feet	1,000 - 600 feet	Required for transition from adverse wave conditions on bar.
Preferred Construction Period	Apr-Oct	Oct	Jul-Oct	Reduce crab mortality. Only period of wave conditions acceptable for dredging operations.
Initial Constr. Equipment	Hopper	Hopper	Hopper	Most economical and only technically feasible way of dredging in adverse wave climate
Initial Constr. 2/ Dredged Material Disposal (1,000's c.y.)	200 c.y. marine sands South Jetty	200 c.y. marine sands to ocean, 8 miles.	200 c.y. marine sands South Jetty	See footnote 3/.

1/Federal authorized channel depth below MLLW. Actual depth at time of dredging would be approximately 4 feet greater due to allowances for advanced maintenance and construction tolerance.

2/Quantities shown include 4 feet of overdepth allowances.

3/South Jetty sites recommended due to being more economical than transporting material across the bar, restriction on crossing the bar due to adverse weather from November to March, the net movement of the material is to the ocean, material is needed to help protect the South Jetty from being undercut due to scour, and the finite capacity of the Point Chehalis site.

TABLE 3-2 (con.)

Project Feature	Alt. 2a NED Plan	Alt. 2b LED Plan	Alt. 2c Recommended Plan	Recommended Plan Principal Rationale
Entrance Reach (Harbor mile 19.4 to harbor mile 15.4) (con.)				
Initial Constr. Cost ($\$10^6$)1/	.25	.58	.25	
Existing O&M		None required		
New Annual O&M Material Disposal2/	Maintenance dredging not anticipated this reach (disposal location, shown if required)			
	(South Jetty)	(8 miles)	(South Jetty)	
New Total Annual O&M Cost ($\$10^6$)1/	(0)	(0)	(0)	

1/Does not include allowances for contingencies and E&D and S&A.
2/Operation and maintenance dredging schedules and operating conditions assumed to be as currently allowed by established procedures.

TABLE 3-2 (con.)

Project Feature	Alt. 2a NED Plan	Alt. 2b LED Plan	Alt. 2c Recommended Plan	Recommended Plan Principal Rationale
South Reach (Harbor mile 15.4 to harbor mile 11.9)				
Authorized Depth 1/	38 feet	38 feet	38 feet	Economically optimum channel depth
Width	400 feet	400 feet	400 feet	Minimum Corps criteria
Preferred Construction Period	Aug-Mar	Aug-Mar	Aug-Mar	Avoid juvenile and adult crabs
Initial Constr. Equipment	Hopper	Clamshell	Hopper	Most economical
Initial Constr. 2/ Dredged Material Disposal (1,000's c.y.)	3,400 c.y. marine sands to Point Chehalis and South Jetty	3,400 c.y. marine sands to ocean 8 miles	3,400 c.y. marine sands to Point Chehalis and South Jetty	See footnotes 3/ and 4/.
Initial Constr. Cost ($$10^6$) 5/	4.76	9.52	4.76	
Existing Annual O&M (1,000 c.y.)	400 c.y. disposed at existing Point Chehalis site.			

1/Federal authorized channel depth below MLLW. Actual depth at time of dredging would be approximately 4 feet greater due to allowances for advanced maintenance and construction tolerance.

2/Quantities shown include 4 feet of overdepth allowances.

3/Point Chehalis sites recommended due to being more economical, net movement of the material is to the ocean, material is needed to help protect the South Jetty from being undercut, restriction on crossing the bar due to adverse weather from November to March, and the finite capacity of the Point Chehalis site.

4/South Jetty sites recommended due to being more economical than transporting material across the bar, restriction on crossing the bar due to adverse weather from November to March, the net movement of the material is to the ocean, material is needed to help protect the South Jetty from being undercut due to scour, and the finite capacity of the Point Chehalis site.

5/Does not include allowances for contingencies and E&D and S&A.

TABLE 3-2 (con.)

Project Feature	Alt. 2a NED Plan	Alt. 2b LED Plan	Alt. 2c Recommended Plan	Recommended Plan Principal Rationale
South Reach (Harbor mile 15.4 to harbor mile 11.9) (con.)				
New Annual O&M Material Disposal1/ (1,000's c.y.)	450 c.y. sands Point Chehalis	450 c.y. sands ocean 8 miles	450 c.y. sands Point Chehalis	See footnote 2/.
New O&M Frequency and Location	(same as existing)			
New Total Annual O&M Cost ($\$10^6$)3/	.6075	1.260	.6075	

1/Operation and maintenance dredging schedules and operating conditions assumed to be as currently allowed by established procedures.

2/Point Chehalis sites recommended due to being more economical, net movement of the material is to the ocean, material is needed to help protect the South Jetty from being undercut, restriction on crossing the bar due to adverse weather from November to March, and the finite capacity of the South Jetty site.

3/Does not include allowances for contingencies and E&D and S&A.

TABLE 3-2 (con.)

Project Feature	Alt. 2a NED Plan	Alt. 2b LED Plan	Alt. 2c Recommended Plan	Recommended Plan Principal Rationale
Crossover Reach (Harbor mile 11.9 to harbor mile 8.5)				
Authorized Depth 1/	38 feet	38 feet	38 feet	Economically optimum channel depth
Width	400 feet	400 feet	400 feet	Minimum Corps criteria
Preferred Construction Period	Mar-Sep	Jul-Sep May-Oct	Oct-Dec Jun-Jul	Avoid crabs
Initial Constr. Equipment	Hopper	Clamshell	Hopper	Most economical
Initial Constr. 2/ Dredged Material Disposal (1,000's c.y.)	2,900 c.y. of ocean sands and some sandy silts to Point Chehalis and South Jetty	2,900 c.y. of ocean sands and some sandy silts to ocean 8 miles	2,900 c.y. of ocean sands and some sandy silts to Point Chehalis and South Jetty	See footnotes 3/ and 4/.
Initial Constr. Cost ($\$10^6$) 5/	5.22	8.555	5.22	
Existing Annual O&M (1,000 c.y.)	400 c.y. disposed at existing Point Chehalis site.			

1/Federal authorized channel depth below MLLW. Actual depth at time of dredging would be approximately 4 feet greater due to allowances for advanced maintenance and construction tolerance.

2/Quantities shown include 4 feet of overdepth allowance.

3/Point Chehalis sites recommended due to being more economical, net movement of the material is to the ocean, material is needed to help protect the South Jetty from being undercut, restriction on crossing the bar due to adverse weather from November to March, and the finite capacity of the Point Chehalis site.

4/South Jetty sites recommended due to being more economical than transporting material across the bar, restriction on crossing the bar due to adverse weather from November to March, the net movement of the material is to the ocean, material is needed to help protect the South Jetty from being undercut due to scour, and the finite capacity of the Point Chehalis site.

5/Does not include allowances for contingencies and E&D and S&A.

TABLE 3-2 (con.)

Project Feature	Alt. 2a NED Plan	Alt. 2b LED Plan	Alt. 2c Recommended Plan	Recommended Plan Principal Rationale
Crossover Reach (Harbor mile 11.9 to harbor mile 8.5) (con.)				
New Annual O&M Material Disposal 1/ (1,000's c.y.)	450 c.y. of sandy silt to Point Chehalis	450 c.y. of sandy silt to ocean 8 miles	450 c.y. of sandy silt to Point Chehalis	See footnote 2/.
New O&M Frequency and Location	(same as existing)			
New Total Annual O&M Cost ($\$10^6$) 3/	.7875	1.3275	.7875	

1/Operation and maintenance dredging schedules and operating conditions assumed to be as currently allowed by established procedures.

2/Point Chehalis sites recommended due to being more economical, net movement of the material is to the ocean, material is needed to help protect the South Jetty from being undercut, restriction on crossing the bar due to adverse weather from November to March, and the finite capacity of the Point Chehalis site.

3/Does not include allowances for contingencies and E&D and S&A.

TABLE 3-2 (con.)

Project Feature	Alt. 2a NED Plan	Alt. 2b LED Plan	Alt. 2c Recommended Plan	Recommended Plan Principal Rationale
Moon Island Reach (Harbor mile 8.5 to harbor mile 5.7)				
Authorized Depth 1/	38 feet	38 feet	38 feet	Economically optimum channel depth
Width	350 feet	350 feet	350 feet	Minimum Corps criteria
Preferred Construction Period	Apr-Sep	May-Jun	Nov-May	Minimize crab impacts (coarser seaward material to be dredged Jan-Mar)
Initial Constr. Equipment	Hopper	Clamshell	Clamshell/hopper	Less risk of water quality problem. Possibly hopper at outer end to facilitate equipment scheduling.
Initial Constr. 2/ Dredged Material Disposal (1,000's c.y.)	1,900 c.y. silty sand to Point Chehalis-South Jetty	1,900 c.y. silty sand to ocean 8 miles	1,900 c.y. silty sand to South Jetty	See footnote 3/.
Initial Constr. Cost ($\$10^6$) 4/	3.895	5.70	4.465	
Existing Average Annual O&M (1,000's c.y.)	150 c.y. disposed at existing Point Chehalis site (dredge cycle every 2 years).			

1/Federal authorized channel depth below MLLW. Actual depth at time of dredging would be approximately 4 feet greater due to allowances for advanced maintenance and construction tolerance.
2/Quantities shown include 4 feet of overdepth allowances.
3/South Jetty site recommended due to being more economical than transporting material across the bar, restriction on crossing the bar due to adverse weather from November to March, the net movement of the material is to the ocean, material is needed to help protect the South Jetty from being undercut due to scour, and the finite capacity of the Point Chehalis sites.
4/Does not include allowances for contingencies and E&D and S&A.

TABLE 3-2 (con.)

Project Feature	Alt. 2a NED Plan	Alt. 2b LED Plan	Alt. 2c Recommended Plan	Recommended Plan Principal Rationale
Moon Island Reach (Harbor mile 8.5 to harbor mile 5.7) (con.)				
New Annual O&M Material Disposal 1/ (1,000's c.y.)	200 c.y. silty sand to Point Chehalis South Jetty	200 c.y. silty sand to ocean 8 miles	200 c.y. silty sand to Point Chehalis and South Jetty	See footnotes 2/ and 3/.
New O&M Frequency and Location	(same as existing)			
New Total Annual O&M Cost ($$10^6$) 4/	.404	.60	.416	

1/Operation and maintenance dredging schedules and operating conditions assumed to be as currently allowed by established procedures.

2/Point Chehalis sites recommended due to being more economical, net movement of the material is to the ocean, material is needed to help protect the South Jetty from being undercut, restriction on crossing the bar due to adverse weather from November to March, and the finite capacity of the South Jetty site.

3/South Jetty sites recommended due to being more economical than transporting material across the bar, restriction on crossing the bar due to adverse weather from November to March, the net movement of the material is to the ocean, material is needed to help protect the South Jetty from being undercut due to scour, and the finite capacity of the Point Chehalis site.

4/Does not include allowances for contingencies and E&D and S&A.

TABLE 3-2 (con.)

Project Feature	Alt. 2a NED Plan	Alt. 2b LED Plan	Alt. 2c Recommended Plan	Recommended Plan Principal Rationale
Hoquiam Reach (Harbor mile 5.7 to harbor mile 2.5)1/				
Depth2/	38 feet	38 feet	38 feet	Economically optimum channel depth
Width	350 feet	350 feet	350 feet	Minimum Corps criteria
Preferred Construction Period	May-Oct	May-Oct	May-Oct	Avoid shallows per WDF request and avoid crab entrainment
Initial Constr. Equipment	Clamshell	Clamshell	Clamshell	Most economical and environmentally acceptable given deepwater disposal preference
Initial Constr.3/ Dredged Material Disposal (1,000's c.y.)	2,150 c.y. sandy silts to Point Chehalis and South Jetty	2,150 c.y. sandy silts to ocean 8 miles	2,150 c.y. sandy silts to 3-1/2-mile ocean site	See footnote 4/.
Initial Constr. Cost ($$10^6$)5/	5.16	7.095	6.45	

1/Quantities and costs for this reach include the Hoquiam reach turning basin at harbor mile 4.5. Turning basin is 750 feet by 750 feet by 30 feet deep.

2/Federal authorized channel depth below MLLW. Actual depth at time of dredging would be approximately 4 feet greater due to allowances for advanced maintenance and construction tolerance.

3/Operation and maintenance dredging schedules and operating conditions assumed to be as currently allowed by established procedures.

4/For purposes of the feasibility report, the project-related costs of ocean disposal have been estimated for ocean disposal sites located near the entrance to Grays Harbor about 2-1/2 and 3-1/2 miles west of the ends of the Grays Harbor North and South Jetties. Biological, physical, and chemical tests would be conducted at several potential ocean disposal sites (including these sites) during the CP&E stage of this project. Resource agencies have agreed that an acceptable site exists within 8 miles from the entrance to Grays Harbor. A final decision on the location of the disposal site or sites would be based on CP&E studies. Ocean disposal is preferred for silty material.

5/Does not include allowances for contingencies and E&D and S&A.

TABLE 3-2 (con.)

Project Feature	Alt. 2a NED Plan	Alt. 2b LED Plan	Alt. 2c Recommended Plan	Recommended Plan Principal Rationale
Hoquiam Reach (Harbor mile 5.7 to harbor mile 2.5)1/ (con.)				
Existing Average Annual O&M (1,000's c.y.)	50 c.y. disposed at existing Point Chehalis site (dredge cycle about every 2 years).			
New Annual O&M Material Disposal2/ (1,000's c.y.)	100 c.y. sandy silt to Point Chehalis-South Jetty	100 c.y. sandy silts to ocean 8 miles	100 c.y. sandy silt to South Jetty	See footnote 3/.
New O&M Frequency and Location	Same as existing, including new turning basin.			
New Total Annual O&M Cost ($$10^6$)4/	.24	.33	.245	

1/Quantities and costs for this reach include the Hoquiam reach turning basin at harbor mile 4.5. Turning basin is 750 feet by 750 feet by 30 feet deep.

2/Point Chehalis sites recommended due to being more economical, net movement of the material is to the ocean, material is needed to help protect the South Jetty from being undercut, restriction on crossing the bar due to adverse weather from November to March, and the finite capacity of the Point Chehalis site.

3/South Jetty sites recommended due to being more economical than transporting material across the bar, restriction on crossing the bar due to adverse weather from November to March, the net movement of the material is to the ocean, material is needed to help protect the South Jetty from being undercut due to scour, and the finite capacity of the Point Chehalis site.

4/Does not include allowances for contingencies and E&D and S&A.

TABLE 3-2 (con.)

Project Feature	Alt. 2a NED Plan	Alt. 2b LED Plan	Alt. 2c Recommended Plan	Recommended Plan Principal Rationale
Cow Point Reach (Harbor mile 2.5 to harbor mile 1.5)1/				
Depth2/	38 feet	38 feet	38 feet	Economically optimum channel depth
Width	350 feet	350 feet	350 feet	Minimum Corps criteria
Preferred Construction Period	Nov-Feb	Jul-Oct	Apr-Oct	Only season for bar crossing. Gravels dredged in April.
Initial Constr. Equipment	Clamshell	Clamshell	Clamshell	Most economical and environmentally acceptable given deepwater disposal preference
Initial Constr.3/ Dredged Material Disposal (1,000's c.y.)	700 c.y. gravels and silts to Point Chehalis or South Jetty	700 c.y. gravels and silts to ocean, 8 miles	200 c.y. gravels4/ to Point Chehalis, 500 silts to 3-1/2-mile ocean site.	See footnote 5/.
Initial Constr. Cost ($$10^6$)6/	2.275	3.330	2.625	
Existing Average Annual O&M (1,000's c.y.)	150 c.y. disposed at existing Point Chehalis site (dredge cycle about every 2 years).			

1/Quantities and costs for this reach include the Cow Point turning basin at harbor mile 2.0. Turning basin would be 1,000 feet by 1,000 feet by 38 feet deep.

2/Federal authorized channel depth below MLLW. Actual depth at time of dredging would be approximately 4 feet greater due to allowances for advanced maintenance and construction tolerance.

3/Quantities shown include 4 feet of overdepth allowances.

4/Gravels are potential resource that will be reconsidered during CP&E for structural or landfill use.

5/For purposes of the feasibility report, the project-related costs of ocean disposal have been estimated for ocean disposal sites located near the entrance to Grays Harbor about 2-1/2 and 3-1/2 miles west of the ends of the Grays Harbor North and South Jetties. Biological, physical, and chemical tests would be conducted at several potential ocean disposal sites (including these sites) during the CP&E stage of this project. Resource agencies have agreed that an acceptable site exists within 8 miles from the entrance to Grays Harbor. A final decision on the location of the disposal site or sites would be based on CP&E studies. Ocean disposal is preferred for silty material.

6/Does not include allowances for contingencies and E&D and S&A.

TABLE 3-2 (con.)

Project Feature	Alt. 2a NED Plan	Alt. 2b LED Plan	Alt. 2c Recommended Plan	Recommended Plan Principal Rationale
Cow Point Reach (Harbor mile 2.5 to harbor mile 1.5)1/ (con.)				
New Annual O&M Material Disposal2/ (1,000's c.y.)	200 c.y. sandy silt to Point Chehalis-South Jetty	200 c.y. sandy silts to ocean, 8 miles	200 c.y. sandy silt to South Jetty	See footnote 3/.
New O&M Frequency and Location	Same as existing			
New Total Annual O&M Cost ($$10^6$)4/	.50	.740	.510	

1/Quantities and costs for this reach include the Cow Point turning basin at harbor mile 2.0. Turning basin would be 1,000 feet by 1,000 feet by 38 feet deep.

2/Operation and maintenance dredging schedules and operating conditions assumed to be as currently allowed by established procedures.

3/South Jetty sites recommended due to being more economical than transporting material across the bar, restriction on crossing the bar due to adverse weather from November to March, the net movement of the material is to the ocean, material is needed to help protect the South Jetty from being undercut due to scour, and the finite capacity of the Point Chehalis site.

4/Does not include allowances for contingencies, E&D and S&A.

TABLE 3-2 (con.)

Project Feature	Alt. 2a NED Plan	Alt. 2b LED Plan	Alt. 2c Recommended Plan	Recommended Plan Principal Rationale
Aberdeen Reach (Harbor mile 1.5 to harbor mile 0)				
Depth 1/	36 feet	36 feet	36 feet	Economically optimum channel depth
Width	250 feet	250 feet	250 feet	Corps minimum criteria
Preferred Construction Period	Mar-May	Jul-Oct	Jul-Oct	Only feasible period for bar crossings and avoid crabs and shallow subtidal areas per WDF request
Initial Constr. Equipment	Clamshell	Clamshell	Clamshell	Most economical and environmentally acceptable given deepwater disposal preference
Initial Constr. 2/ Dredged Material Disposal (1,000's c.y.)	550 c.y. sandy silts to ocean, 2-1/2-mile site	550 c.y. sandy silts to ocean, 8 miles	550 c.y. sandy silts to ocean 3-1/2-mile site	See footnote 3/.
Cost ($10^6) 4/	1.87	2.255	1.925	
Existing Average Annual O&M (1,000's c.y.)	50 c.y. disposed at existing Point Chehalis site (dredge cycle about every 5 years).			

1/Federal authorized channel depth below MLLW. Actual depth at time of dredging would be approximately 4 feet greater due to allowances for advanced maintenance and construction tolerance.

2/Quantities shown include 4 feet of overdepth allowances.

3/For purposes of the feasibility report, the project-related costs of ocean disposal have been estimated for ocean disposal sites located near the entrance to Grays Harbor about 2-1/2, 3-1/2 and 8 miles west of the ends of the Grays Harbor North and South Jetties. Biological, physical, and chemical tests would be conducted at several potential ocean disposal sites (including these sites) during the CP&E stage of this project. Resource agencies have agreed that an acceptable site exists within 8 miles from the entrance to Grays Harbor. A final decision on the location of the disposal site or sites would be based on CP&E studies. Ocean disposal is preferred for silty material.

4/Does not include allowances for contingencies, E&D and S&A.

TABLE 3-2 (con.)

Project Feature	Alt. 2a NED Plan	Alt. 2b LED Plan	Alt. 2c Recommended Plan	Recommended Plan Principal Rationale
Aberdeen Reach (Harbor mile 1.5 to harbor mile 0)				
New Annual O&M Material Disposal 1/ (1,000's c.y.)	50 c.y. sandy silts to Point Chehalis-South Jetty	50 c.y. sandy silts to ocean 8 miles	50 c.y. sandy silts to South Jetty	See footnote 2/.
New O&M Frequency and Location	Same as existing			
New Total Annual O&M Cost ($$10^6$) 3/	.131	.205	.135	

1/Operation and maintenance dredging schedules and operating conditions assumed to be as currently allowed by established procedures.

2/South Jetty sites recommended due to being more economical than transporting material across the bar, restriction on crossing the bar due to adverse weather from November to March, the net movement of the material is to the ocean, material is needed to help protect the South Jetty from being undercut due to scour, and the finite capacity of the Point Chehalis site.

3/Does not include allowances for contingencies, E&D and S&A.

TABLE 3-2 (con.)

Project Feature	Alt. 2a NED Plan	Alt. 2b LED Plan	Alt. 2c Recommended Plan	Recommended Plan Principal Rationale
South Aberdeen Reach (River mile 0 to river mile 2.3)1/				
Depth2/	36 feet	36 feet	36 feet	Economically optimum channel depth
Width	250 feet	250 feet	250 feet	Minimum by Corps criteria
Preferred Construction Period	Aug-Feb	Jul-Oct	Jul-Dec	Avoid crab immigration and intertidal and shallow tidal areas per WDF request.
Initial Construction Equipment	Pipeline/ Clamshell	Clamshell	Clamshell	Most environmentally acceptable and economical given deepwater disposal preference.
Initial Constr.3/ Dredged Material Disposal (1,000's c.y.)	1,000 c.y. sandy silts to upland site 300 c.y. silt to South Jetty	1,300 c.y. sandy silts to ocean, 8 miles	1,300 c.y. sandy silts to South Jetty	See footnote 5/.
Initial Constr. Cost ($\$10^6$)6/	2.64 + .3 dike4/	6.76	3.835	

1/Quantities and costs for this reach include the South Aberdeen turning basin at river mile 1.4. Turning basin would be 750 feet by 750 feet by 30 feet deep.

2/Federal authorized channel depth below MLLW. Actual depth at time of dredging would be approximately 4 feet greater due to allowances for advanced maintenance and construction tolerance.

3/Quantities shown include 4 feet of overdepth allowances.

4/Dike construction is a non-Federal cost.

5/South Jetty site recommended due to being more economical than transporting material across the bar, restriction on crossing the bar due to adverse weather from November to March, the net movement of the material is to the ocean, material is needed to help protect the South Jetty from being undercut due to scour, and the finite capacity of the Point Chehalis sites.

6/Does not include allowances for contingencies, E&D and S&A.

TABLE 3-2 (con.)

Project Feature	Alt. 2a NED Plan	Alt. 2b LED Plan	Alt. 2c Recommended Plan	Recommended Plan Principal Rationale
South Aberdeen Reach (River mile 0 to river mile 2.3)1/ (con.)				
Existing Average Annual O&M (1,000's c.y.)	50 c.y. disposed at existing Point Chehalis site (dredge cycle about every 5 years).			
New Annual O&M Material Disposal2/ (1,000's c.y.)	100 c.y. sandy silts to Point Chehalis-South Jetty	100 c.y. sandy silts to ocean 8 miles	100 c.y. sandy silts to South Jetty	See footnote 3/.
New O&M Frequency and Location	Same as existing, except turning basin about every 2 years.			
New Total Annual 4/ O&M Costs ($$10^6$)	.2875	.52	.295	

1/Quantities and costs for this reach include the South Aberdeen turning basin at river mile 1.4. Turning basin would be 750 feet by 750 feet by 30 feet deep.

2/Operation and maintenance dredging schedules and operating conditions assumed to be as currently allowed by established procedures.

3/South Jetty sites recommended due to being more economical than transporting material across the bar, restriction on crossing the bar due to adverse weather from November to March, the net movement of the material is to the ocean, material is needed to help protect the South Jetty from being undercut due to scour, and the finite capacity of the Point Chehalis site.

4/Does not include allowances for contingencies, E&D and S&A.

TABLE 3-2 (con.)

Project Feature	Alt. 2a NED Plan	Alt. 2b LED Plan	Alt. 2c Recommended Plan	Recommended Plan Principal Rationale
Railroad Bridge (Harbor and river mile 0)				
Horizontal Clearance	250 feet	250 feet	250 feet	Minimum required to accommodate construction on present alinement
Vertical Clearance	140 feet above MHHW	140 feet above MHHW	140 feet above MHHW	Minimum recommended by U.S. Coast Guard
Cost ($\$10^6$)1/	23.869	23.869	23.869	
Highway Bridge (River mile .1)				
Fenders				Protect highway bridge from possible impact due to passage of large vessels after railroad bridge replacement.
Cost (10^6)2/	.81	.81	.81	
Aids to Navigation3/	$310,000	$310,000	$310,000	Recommended by U.S. Coast Guard
Mitigation Measures	$550,000	$550,000	$550,000	Replace lost shallow subtidal acreage and modify dredge equipment and/or other acceptable means to reduce crab mortality.
Berth Dredging4/ **and Disposal**	$830,000	$830,000	$830,000	Dredging by locals at existing terminal facilities to make depth of berths comparable with channel depth.

1/Total cost including contingencies, E&D, S&A, and $669,000 for utility relocations.
2/Total cost including contingencies, E&D, and S&A.
3/Additional aids to navigation.
4/Operation and maintenance dredging schedules and operating conditions assumed to be as currently allowed by established procedures.

TABLE 3-3

SYSTEM OF ACCOUNTS COMPARISON OF ALTERNATIVE PLANS

ACCOUNTS	ALTERNATIVE 1 (No Action)	ALTERNATIVE 2a (NED Plan)	ALTERNATIVE 2b (LED Plan)	ALTERNATIVE 2c (Recommended Plan)
1. National Economic Development (NED) Criteria				
a. Benefits (Average Annual)				
Economics of Scale	Foregone	$14,067,000	$14,067,000	$14,067,000
Safety Improvement	None	Yes, not quantified	Yes, not quantified	Yes, not quantified
TOTAL BENEFITS	N/A	$14,067,000	$14,067,000	$14,067,000
b. Total Construction Costs1/		$66,660,000	$95,200,000	$71,300,000
c. Average Annual Costs				
Interest and Amortization of Investment Costs2/	N/A	$5,215,000	$7,450,000	$5,580,000
Interest During Construction (Amorized)	N/A	None	$890,000	None
Operation and Maintenance3/	Base condition	$2,330,000	$5,740,000	$2,500,000
TOTAL COSTS	$4,465,000	$7,545,000	$14,080,000	$8,080,000

1/Includes allowances for contingencies and engineering and design and supervision and administration.
2/Based on 7-5/8 percent interest rate.
3/O&M costs shown are for project costs exceeding the base condition of present project maintenance costs.

TABLE 3-3 (con.)

ACCOUNTS	ALTERNATIVE 1 (No Action)	ALTERNATIVE 2a (NED Plan)	ALTERNATIVE 2b (LED Plan)	ALTERNATIVE 2c (Recommended Plan)
c. Net Benefits (Average Annual Benefits Minus Average Annual Costs)	N/A	$6,522,000	$-13,000	$5,987,000
d. Benefit-to-Cost Ratio	N/A	1.9 to 1	0.99 to 1	1.7 to 1
2. Environmental Quality (EQ) Criteria				
a. Preserve Wetlands per Executive Order 11990	Continue existing trends	Possible impact on outer harbor wetlands	Continue existing trends	Continue existing trends
b. Maintain or Improve Area Fishery Resource	Continue existing trends	Possible adverse impact on area crab resource	Minimal adverse impact on area crab resource	Acceptable adverse impact on area crab resource
c. Comply with State Coastal Zone Management Program	Does comply	Would comply	Would comply	Would comply
d. Protect Threatened or Endangered Species and Their Habitat	No impact	No impact	No impact	No impact
e. Maintain Existing Air Quality	Continue existing trends.	Continue existing trends	Continue existing trends	Continue existing trends
f. Protect Ocean Ecology	Continue existing trends	Possible adverse impact to clam resource and crab fishery	Minimal adverse impact to clam resource and crab fishery	Possible adverse impact to clam resource and crab fishery

TABLE 3-3 (con.)

ACCOUNTS	ALTERNATIVE 1 (No Action)	ALTERNATIVE 2a (NED Plan)	ALTERNATIVE 2b (LED Plan)	ALTERNATIVE 2c (Recommended Plan)
3. Regional Development (RD) Criteria				
a. Increase Employment in Grays Harbor County	May cause decrease	May increase during and after construction	May increase during and after construction	May increase during and after construction
b. Increase Net Income to Businesses in Grays Harbor County	Continue existing trends and cause decrease	Increase business income	Increase business income	Increase business income
c. Increase per Capita Income	Continue existing trends and cause decrease	May increase income	May increase income	May increase income
d. Increase Property Values Within the Study Area	Continue existing trends and cause decrease	Increase property values	Increase property values	Increase property values
e. Increase Tax Revenues Within the Study Area	Continue existing trends and cause decrease	Increase revenue	Increase revenue	Increase revenue
4. Other Social Effects (OSE) Criteria				
a. Avoid the Relocation of Residential Properties	Continue existing trends	Yes	Yes	Yes
b. Avoid the Relocation of Public Facilities and Resulting Inconveniences During Construction	Continue existing trends	Minor disruption during RR bridge construction	Minor disruption during RR bridge construction	Minor disruption during RR bridge construction

SECTION 4. THE RECOMMENDED PLAN

4.01 Plan Description. The recommended plan for navigation improvement is shown on plate 1. About 24.3 miles of existing authorized Federal navigation channel would be widened and deepened, beginning with 2.6 miles of the outer bar and continuing through the harbor to Aberdeen and up the Chehalis River to Cosmopolis. Improvements by navigation channel reach are shown on plates 1 and 3 through 6 and described in table 3-2. In addition to channel improvements the recommended plan includes:

- dredging of a turning basin at Hoquiam (see plates 1 and 6),
- widening and deepening of the existing widened channel at Cow Point into a turning basin (see plates 1 and 6),
- dredging of a turning basin near the mouth of Elliott Slough (see plates 1 and 6),
- replacement of the UPRR bridge at Aberdeen (see plate 8),
- installation of additional fenders at the State Highway 101 bridge,
- mitigation of lost shallow-water fish feeding and rearing habitat through development of replacement habitat[1/], and
- mitigation of increased juvenile and adult crab mortalities through dredging equipment modifications.

Dredged material would be disposed of at new Point Chehalis designated disposal sites, a South Jetty site, and in the ocean about 3-1/2 miles from the harbor entrance (see plates 3 and 7). Placement of dredged material at the Point Chehalis and South Jetty disposal sites would help alleviate the existing potential of the South Jetty being undermined through tidal scouring action. Engineering, design, and detailed cost estimates are contained in appendix D.

4.02 Navigation Conditions. Channel dimensions, channel alinement, and turns affect navigation conditions as well as tides, river currents, wind, and fog. The existing Federal navigation channel dimensions are shown in table 3-1. See paragraph 4.06 for discussions of shoaling and

1/Exact location of replacement habitat site will be determined during CP&E. However, for purposes of preparing an cost estimate for the feasibility report, a potential site was located above the UPRR bridge in the general vicinity of the project.

other harbor characteristics of concern to navigation. Also see appendix D for further information. The improved channel would have an authorized depth of 38 feet MLLW (except greater in the entrance and bar reaches) up to harbor mile (H.M.) 1.5 at Aberdeen and an authorized depth of 36 feet MLLW from H.M. 1.5 to river mile (R.M.) 2.3 at Cosmopolis. Channel alinement fully utilizes natural scour in order to minimize maintenance dredging.

4.03 Tides and Currents.

a. Tides. Tides at Grays Harbor are the mixed type typical of the Pacific coast of North America (two unequal high and low waters occurring each day). Mean diurnal ranges are 8.5 feet at the ocean entrance and 10.1 feet at Aberdeen. High and low tides at Aberdeen occur about 1 hour later than at the ocean entrance.

b. Currents. Currents in the upper estuary are generally about 3 feet per second (f.p.s.) on both ebb and floodflows, with maximum currents reaching to about 5 f.p.s. Currents generally aline with the channel in the upper harbor except some crosscurrents do occur at channel bends. In the outer harbor, crosscurrents are severe and adversely affect navigation downstream of the Moon Island reach.

4.04 Winds. Prevailing winds in Grays Harbor are generally moderate to light and from the northwest and north in summer, and southeasterly to southwesterly in winter. Winter storms do (5 to 8 percent of the time) produce winds of gale force from the southeast and southwest. Wind rose and estimated maximum wind velocity-duration curves for Westport are shown in appendix D, figures D1-1 and D1-2.

4.05 Waves. The existing and proposed outer harbor and bar channels are exposed to deepwater generated waves from the northwest, west to southwest. Wind generated waves in the harbor are limited by fetch length and the shallow water of the estuary. Wind generated waves have little effect on deep-draft transit because of the relatively short wave periods, 2 to 4 seconds. Vessel generated waves are generally less than 3 feet in height. See appendix D for further detail.

4.06 Hydraulics. Grays Harbor estuary is roughly "pear-shaped" and is about 11 miles wide and about 15 miles long. The estuary has large expanses of tidal flats and numerous ebb channels with a water area of about 90 square miles at MHHW and 38 square miles at MLLW. Grays Harbor is a partially mixed estuary influenced by tide action and freshwater inflow to the harbor. The Chehalis River is the predominant freshwater source to the estuary with average flows of about 10,000 cubic feet per second (c.f.s.) and extremes from lows of 1,000 c.f.s. in late summer to highs of over 50,000 c.f.s. in winter. Freshwater and denser seawater often result in a stratified water column in the upper harbor reaches but becomes fairly well-mixed in the lower harbor area. The existing navigation channel generally follows the natural estuary depths but undergoes continuous shoaling. In the upper harbor area shoaling results from freshwater sedimentation sources and from saltwedge transport and

settling of material; in the outer harbor area marine sediments become the predominant shoal material. At present, shoaling of channels inside the harbor requires about 1.25 million c.y. average annual dredging. Future maintenance within the harbor resulting from further widening and deepening under the recommended plan is expected to increase this requirement to about 1.55 million c.y. per year. The harbor entrance is fixed by two convergent jetties--the North Jetty, 17,200 feet long, and South Jetty, 13,734 feet long--which constrict the entrance width to about 6,500 feet. These jetties function very well in maintaining the entrance channel and outer bar through ebbtide scour and by reducing the inflow of ocean sediments into the estuary. Maintenance dredging of the entrance channel and outer bar is not now required, but with deepening required on the bar, future maintenance of 800,000 c.y. per year is expected. Therefore, future maintenance dredging inside the harbor and on the outer bar will total about 2.35 million c.y.

4.07 To provide information for the design of the improved navigation channel, fixed-bed model tests (scale 1:500 horizontal (H), 1:100 vertical (V)) were conducted by the Hydraulics Laboratory of the U.S. Army Corps of Engineers Waterways Experiment Station (WES), Vicksburg, Mississippi, from 1968 through 1976.1/ The comprehensive Grays Harbor estuary model was used to determine the effects of a number of project features, e.g., South reach realinement, North and South Jetty rehabilitation, and Westport Marina expansion in addition to the channel enlargement (deepening and widening) studies. Studies undertaken for channel enlargement consisted of: salinity changes, tide and current changes, sedimentation, water circulation, and structural methods of reducing shoaling. Model studies tended to show that significant changes will not result from channel enlargement. Only a slight increase in sedimentation is anticipated. Hydraulic changes are essentially limited to the confines of the improved channel. The most significant hydraulic change would be to the saltwater wedge intrusion in the upper estuary. Salinity near the bottom will intrude further upstream compared to existing limits of intrusion under some flow conditions. Only a minor change will occur under low freshwater inflow conditions, but the change will be on the order of 2-3 miles with high freshwater inflow. Details of hydraulic studies and their results are discussed further in appendix D.

4.08 Geotechnical Considerations. Grays Harbor is a drowned coastal valley sheltered from ocean wave attack by bay mouth bars. The surrounding uplands consist of deeply weathered Tertiary sandstone, siltstone, and marine lava flows truncated by weathered Pleistocene sand and gravel. Thick alluvium underlies the valley floors of the major tributary streams. The bedrock surface is highly irregular reflecting former

1/Reference Technical Report H-72-2, "Grays Harbor Estuary, Washington," reports 1 through 6. Test results are detailed in the 1976 feasibility report and summarized in appendix D.

deeply incised drainages which developed during the Pleistocene ice age while sea level was about 200 feet lower and coastline about 20 miles west of its present position. The rise of sea level and drowning of coastal valleys was accompanied by sea cliff development until coastal "streamlining" was accomplished by the deposition of coastal littoral sand and the formation of the bay mouth bars effectively closing the mouth of the harbor. This permitted development of a colluvial shelf at the base of the old sea cliffs as well as the accumulation of a thick sequence of estuarine sands and silts (principally from the Chehalis Basin and Columbia River) in the harbor. Continued accumulation of these sediments is resulting in a slow filling of the harbor. The North and South Jetties, initially constructed in the late 1890's, have altered tidal currents and wave action at the outer bar and entrance reaches, resulting in a reduced influx of Columbia River sediments. The jetty system provides scour depths of over 60 feet MLLW in the south entrance area between the jetties and over 35 feet MLLW on the outer bar.

4.09 Dredged Materials and Channel Sideslopes. Generally, the foundation materials to be dredged will consist of medium dense to dense fine sands and silty sands with surficial soft silts and some zones of gravel, except dredging in the Cow Point reach will encounter very dense sand, very dense gravels, and probably some glacial till and/or weathered sandstone bedrock. Sideslopes along the existing channel vary from 1 V on 4 H for silts to 1 V on 3 H for sands and 1 V on 2 H for gravels. The predominant foundation materials are sands. Based on the foundation exploration data to date and existing sideslopes, a 1 V on 3 H slope has been used for preliminary design studies, except in the South and Crossover reaches where a 1 V on 5 H slope would be used and in the outer bar area where a 1 V on 10 H slope would be used. Outer bar sideslopes would be flattened to prevent rapid shoaling along the channel edge from high littoral drift volumes and high wave energy exposure. Channel dredging will not require slope protection.

4.10 Chemical and Biological Testing of Dredged Material. Chemical testing of inner harbor sediments was accomplished in 1980-1981. Results of the testing showed that the concentration of the majority of contaminants was relatively low. Details of chemical and physical testing of materials are included in Chemical Testing of Sediments in Grays Harbor, Washington, A.M. Test, Inc., September 1981. Biological tests of the Grays Harbor sediments to evaluate potential mortality and chemical uptake (bioaccumulation) effects during disposal are ongoing as part of the feasibility studies. Preliminary results do not indicate significant chemical toxicity associated with the sediments (reference exhibit 2 of appendix A). Completed results of these tests will be distributed in June 1982. If significant contaminant effects are found during these tests, dredged material would be placed in contained upland disposal sites in the upper harbor area (see plate 7 and appendix D).

4.11 Design Criteria. The major navigation channel design concerns are the channel width, depth, and alinement which are related to vessel characteristics and environmental conditions at the project. The channel should meet most current and future navigation traffic needs without

undue vessel delays or unsafe conditions. Selection of channel depth involves consideration of the loaded draft of expected vessels, vessel squat or sinkage, vessel trim, maneuverability, water salinities, wave action, and type of channel bottom. Selection of channel width involves consideration of the width of expected vessels, traffic volumes, vessel maneuverability, channel alinement, minimum speed, vessel capability, characteristics of available tug assists, and views of individual vessel pilots. Channel design also includes consideration of impacts on fish and wildlife. The determination of optimum channel size is based upon a comparison of economic benefits of improved safety and reduced transportation costs compared with the cost of providing successively larger increments of enlarged, improved channel. The design vessel for that portion of the channel from the ocean to port terminals at Cow Point has a loaded draft of 35 feet, a length of 625 feet, and a beam of 90 feet. Larger vessels, such as the Hoegh class vessels with 37 feet draft, 658 feet length and 101 feet beam, are expected to occasionally call at Grays Harbor. Vessels of this size will require tide delays and favorable environmental conditions to navigate the channel safely, when fully loaded. The design vessel for the channel above Cow Point to Cosmopolis has a loaded draft, length, and beam of 34 feet, 600 feet, and 90 feet, respectively. Data on the composition of the future fleet can be found in appendix C. Additional information on navigation channel design criteria can be found in appendix D.

4.12 Structural Features. The structural features of the navigation improvement plan are shown on plates 3 through 8 and are described in detail in appendix D. Major structural features include the following:

a. Channel Improvements. The deep-draft navigation channel at Grays Harbor would be improved as follows: Outer Bar reach widened and deepened to 1,000 feet by 46 feet, Entrance reach widened and deepened to 1,000 feet to 600 feet by 46 to 38 feet, South reach widened and deepened to 400 feet by 38 feet, Crossover reach widened and deepened to 400 feet by 38 feet, Moon Island reach deepened to 38 feet, Hoquiam reach deepened to 38 feet, Cow Point reach deepened to 38 feet, Aberdeen reach widened and deepened to 250 feet by 36 feet, and South Aberdeen reach widened and deepened to 250 feet by 36 feet.

b. Turning Basin Improvements. At present, turning of vessels is very restricted and accomplished in naturally deep portions of the channel either in a light-loaded condition and/or at high tides. Existing designated turning basins include a 550-foot-wide by 1,000-foot-long, 30-foot-deep basin near the head of the deep-draft navigation at Cosmopolis, and a 600-foot-wide by 1,000-foot-long, 30-foot-deep basin at Aberdeen, below the UPRR bridge. Neither turning basin is maintained nor used by pilots. In December 1981, widening to 800 feet was authorized of a 600-foot-wide section of the existing Cow Point reach channel.1/ It is anticipated that this improvement will be accomplished

1/Fiscal Year 1982 Energy and Water Development Act (Public Law 97-88, 4 December 1981).

in Fiscal Year 1982. The recommended plan provides for: (1) relocating the designated Cosmopolis turning basin about a mile downstream to just above the Highway 101 bridge, near the entrance to Elliott Slough, with dimensions of 750 feet wide by 750 feet long with depth of 30 feet MLLW; (2) relocating the designated Aberdeen turning basin to the widened channel at Cow Point where the turning basin will be 1,000 feet by 1,000 feet with depth of 38 feet MLLW; and (3) dredging a new 750-foot by 750-foot turning basin with depth of 30 feet MLLW in the Hoquiam reach. Location of the turning basins is shown on plates 1 and 6.

c. Railroad Bridge Replacement. The UPRR bridge would be replaced with a vertical lift structure having a horizontal channel clearance of 250 feet and a vertical clearance of 140 feet above MHHW. UPRR Company would be involved with the detailed design and construction of the replacement railroad bridge. Plates 6, 8, and 9 show the location, detailed plan, and schedule of construction features recommended for the vertical lift bridge.

d. Utilities Relocation. Appendix D details the utilities that would require relocation. The utilities generally consist of outfalls, submarine cables, and water and sewerlines.

4.13 Dredge Disposal. The recommended plan would require initial dredging of an estimated 17.1 million c.y. of sand and silt and average annual maintenance dredging of about 2.35 million c.y. of material to maintain proposed channel depths. About 7.2 million c.y. of initial dredging would be disposed in deep water, 3-1/2 miles outside the harbor entrance beyond the 100-foot contour, in the designated vessel traffic lanes to avoid conflicts with commercial fishing activities (see plate 7).1/ The balance of the initial dredging would be placed in the deep scoured areas adjacent to the toe of the South Jetty and at new Point Chehalis sites about .25 and .60 miles southwest of the existing Point Chehalis disposal site.2/ The South Jetty site is located

1/For purposes of the feasibility report, the project-related costs of ocean disposal have been estimated for ocean disposal sites located near the entrance to Grays Harbor about 2-1/2, 3-1/2 and 8 miles west of the ends of the Grays Harbor North and South Jetties. Biological, physical, and chemical tests would be conducted at several potential ocean disposal sites (including these sites) during the CP&E stage of this project. Resource agencies have agreed that an acceptable site exists within 8 miles from the entrance to Grays Harbor. A final decision on the location of the disposal site or sites would be based on CP&E studies. Ocean disposal is preferred for silty material.

2/During CP&E, alternative disposal sites will be re-examined. Included will be a 164 acre confined site located at the west end of Bowermen field as identified in the GHEMP. The capacity of the site is approximately 4.2 million c.y. In addition, the disposition of approximately 200,000 c.y. of gravels to be dredged from the Cow Point reach will be re-examined for possible landfill or structural use.

TABLE 4-1

ESTIMATED DREDGING QUANTITIES
(1,000 cubic yards)

Channel Reach	Approximate Harbor or River Mile From	To	Initial	Average Annual Maintenance
Outer Bar	HM 22.0	HM 19.0	4,000	800
Entrance	HM 19.0	HM 16.0	200	0
South	HM 16.0	HM 11.0	3,400	450
Crossover	HM 11.0	HM 8.0	2,900	450
Moon Island	HM 8.0	HM 6.0	1,900	200
Hoquiam	HM 6.0	HM 2.0	2,150	100
Cow Point	HM 2.0	HM 1.5	700	200
Aberdeen	HM 1.5	HM 0.0	550	50
South Aberdeen	RM 0.0	RM 2.3	1,300	100
Total			17,100	2,350

HM = Harbor Mile
RM = River Mile

TABLE 4-2

CONSTRUCTION DREDGING EQUIPMENT

Reach	Dredging Method	Disposal Site
Outer Bar	Hopper	Ocean
Entrance Channel	Hopper	South Jetty
South	Hopper	South Jetty/Point Chehalis
Crossover	Hopper	South Jetty/Point Chehalis
Moon Island	Clamshell/Hopper	South Jetty
Hoquiam	Clamshell	Ocean
Cow Point	Clamshell1/	Point Chehalis/Ocean
Aberdeen	Clamshell	Ocean
South Aberdeen	Clamshell	South Jetty

1/Speical dredging equipment, such as large backhoe or a ripper, may need to precede the clamshell due to density of material in area of turning basin.

1.5 miles southwest of the existing Point Chehalis site (see plate 3). Material placed at these sites will help reduce the potential loss of the South Jetty due to tidal scouring action. Table 4-1 indicates the estimated quantities of construction and annual maintenance dredging for the various reaches of the proposed project, while table 4-2 indicates the type of dredging equipment to be used during construction. For purposes of this study it was assumed that for ocean disposal, hopper dredges and clamshell dredges which discharge into barges would be used. During CP&E studies, both the type of dredge equipment recommended and dredge scheduling would be reevaluated based on cost and/or environmental concerns and possible adjustments made.

4.14 In accordance with the requirements set forth in Section 150 of the Water Resources Development Act of 1976 (Public Law 94-587), a determination was made regarding the feasibility of establishing wetland areas by using disposal material. No suitable sites were found for this purpose. The establishment of additional wetlands as provided for in Section 150 has been and will be studied further under the ongoing Grays Harbor operation and maintenance program and/or during CP&E.

4.15 Nonstructural Measures. No nonstructural measures are recommended.

4.16 Aids to Navigation. Buoy modifications and additional ranges and day markers are planned as aids to navigation improvements based on recommendations of the U.S. Coast Guard (USCG) (see USCG letter dated 3 December 1981, appendix B). Appendix D identifies navigation aids planned and provides an estimate of associated costs.

4.17 Real Estate. No real estate is required for the Point Chehalis and South Jetty disposal sites as these sites are located on state lands in navigable waters. These sites would be designated as dredged disposal sites by the State of Washington Department of Natural Resources (DNR). The ocean disposal site and Federal channels and turning basins also would require no real estate action as they would be located in navigable waters and therefore allowable under Federal navigation servitude. However, about 4 acres would be acquired by the Port of Grays Harbor for mitigation of lost shallow subtidal habitat, with the Port also responsible for any required maintenance of replacement habitat created on these lands. Leases and rights-of-entry, required for installation of aids to navigation, would be obtained by the Port. No additional lands would be required for the UPRR bridge replacement. Although no wetland or upland disposal is called for in the recommended plan, should CP&E studies result in a plan change, local non-Federal interests would be responsible for securing permanent disposal area easements for future maintenance work.

4.18 Environmental Features. The recommended plan is responsive to environmental concerns through features including dredge scheduling, selection of dredge equipment, selective use of disposal areas, and mitigation measures (see paragraph 4.18a below and section 2 of the EIS).

a. Mitigation. Replacement habitat of about 4 acres is planned for 4 acres of shallow subtidal habitat that would be removed during initial widening of the channel in the Cow Point and South Aberdeen reaches. The tentatively recommended replacement site is located on the Chehalis River, about R.M. 1.8. Mitigation of potential crab losses expected during initial dredging, based on use of existing dredging equipment, would be sought through modification of dredge equipment. If avoidance of the crab loss through modification of dredge equipment is not feasible, other measures to mitigate for crab loss will be evaluated. These other measures could include: increasing natural survival of Dungeness crabs in Grays Harbor, habitat enhancement to increase the survival rate of juvenile crabs, or the increased use of clamshell dredging to reduce crab mortality. Dredge modification studies conducted during CP&E will determine the need for these other measures (see paragraph 4.33).

b. Enhancement. No enhancement measures are planned.

4.19 Cultural Resources. Coordination with the Washington State Office of Archaeology and Historic Preservation indicates that cultural resources may be present in the area but would probably not be impacted by the project (see appendix A). No known historic or archeological sites as recorded in the National Register of Historic Places, the Washington State Register of Historical Places, or the archeological records of the University of Washington, Department of Anthropology, would be affected by the project. In addition to a review of these documents, two cultural resource reconnaissance studies were conducted, one in which potential upland dredged material disposal areas were inspected, and another in which harbor sediment cores were analyzed for indications of habitation. Neither of these studies found evidence of cultural resources in the project area.

4.20 Project Costs. Estimated project costs are summarized in table 4-3 with detailed cost estimates presented in appendix D.

TABLE 4-3

APPORTIONMENT OF ESTIMATED FIRST COST
(October 1981 Price Level)

First Costs	Total Cost	Federal Cost	Non-Federal Cost	Non-Federal Responsibility
Dredging and Disposal	$44,941,000	$44,941,000		
Berth Dredging and Disposal	820,000		$820,000	Port of Grays Harbor/Wood Products Companies
Railroad Bridge	23,200,000	22,410,000	790,000	Union Pacific Railroad Co.
Relocation of Utilities	669,000		669,000	Utility Owners
Highway Bridge Fendering	810,000		810,000	Washington Department of Transportation
Mitigation	550,000 1/	539,000	11,000	Port of Grays Harbor
Aids to Navigation	310,000	310,000		
TOTAL	$71,300,000	$68,200,000	$3,100,000	

1/Cost includes replacement of lost shallow subtidal habitat which is cost shared between Federal and non-Federal interests and dredge equipment modification to reduce Dungeness crab mortality which is a Federal cost. Other mitigation measures discussed in 4.18a, which may be needed depending upon the results of CP&E dredge modification studies, could increase mitigation costs to $1,500,000.

4.21 Design and Construction Schedule. The tentative schedule for plan implementation is shown below. The actual schedule will depend on factors such as length of time required for review of this feasibility report/EIS and congressional authorization of project and subsequent Federal and local sponsor funding decisions.

Completion of Division Engineer's Report	November 1982
Initiate Continuation of Planning and Engineering	October 1984 1/
Initiate Plans and Specifications	March 1987
Advertise Construction	February 1988
Award Contract	April 1988
Complete Construction	May 1990

4.22 Operation, Maintenance, and Replacement. Average annual navigation channel maintenance dredging of an estimated 2.35 million c.y. would be accomplished by the Corps, with dredging schedules and/or operating conditions governed by currently established operation and maintenance dredging procedures. Berthing areas would be maintained by the Port of Grays Harbor and timber products companies. The outer bar channel maintenance dredged material is assumed to be disposed in the ocean disposal sites located 3-1/2 miles from the harbor entrance. For all inner harbor reaches, except Hoquiam and Aberdeen reaches, dredged materials will be placed in a deep scoured area adjacent to the toe of the South Jetty and/or at the relocated Point Chehalis disposal sites (see plate 3). Final dredge disposal determination will be made during CP&E studies. The UPRR Company would operate and maintain the modified railroad bridge and the Washington Department of Transportation (WDOT) would maintain the highway bridge fendering system. Relocated utility crossings would be maintained by the utility owner. Aids to navigation would be maintained by the USCG.

4.23 Economics of the Recommended Plan.

a. Methodology. The economic feasibility of the recommended plan was evaluated by comparing the average annual costs with average annual benefits resulting from the plan. A 50-year period of economic analysis was used in analyzing the recommended project. Benefits and costs were based on October 1981 price levels. The first year of project operation was assumed to be 1990. Benefits would accrue from the first year of operation, 1990, since the shipping benefits are expected to be realized beginning with the first year. Costs of the plan would accrue in different periods of time. Costs and benefits were made comparable by discounting to 1990 and conversion to an average annual equivalent time

1/ CP&E could begin as early as October 1983, assuming funding and continuation of planning approval. This would advance project completion by 1 year.

basis, using the current 7-5/8 percent interest rate prescribed for the analysis of Federal water resource projects. Additional information on the economic analysis for navigation benefits is presented in appendix C.

b. Average Annual Benefits. Benefits to the national economy from the planned channel improvements consist primarily of transportation savings. Savings in transportation costs result from economies of scale through use of larger ships and more fully loaded vessels.

Savings in transportation costs were determined by comparing without project conditions and transportation costs with those that could be expected with channel widening, deepening, and bridge modification. Transportation savings were calculated, using October 1981 O.C.E. vessel operating costs. Benefits and costs of the proposed project were analyzed separately for: (1) the segment of the waterway from the ocean to and including the Cow Point reach and (2) the segment from the Cow Point reach through the Aberdeen and South Aberdeen reaches to Cosmopolis. For each segment, the analysis included assessing benefits and costs at various channel depths to determine the depth at which maximum net benefits would be realized. The recommended plan calls for authorized channel depths for the two segments based on what is economically optimal for each segment.

Benefit derivation and examples of all transportation benefit calculations are presented in appendix C. The estimated average annual benefits accruing from the overall navigation improvement project are as follows (October 1981 price level):

Economies of scale benefits	$14,067,000
Increased safety	improvement not quantified
Total Average Annual Navigation Improvement Benefits	$14,067,000

c. Average Annual Cost. Total Federal project first costs were converted to an average annual basis using a 50-year project life at 7-5/8 percent interest. This resulted in an average annual cost of $5,338,000. The average annual cost of total non-Federal project first costs is $242,000. Average annual increased maintenance costs total $2,500,000 resulting in a total average annual project cost of about $8,080,000. All costs were based on October 1981 price levels. Since construction would be accomplished in about 2 years, the interest during construction is not a project cost.

d. Economic Justification. A benefit-to-cost ratio of 1.7 to 1.0 was calculated for the total project, using average annual benefits of $14,067,000 and an average annual cost of $8,080,000. Appendix C presents the economic justification of the project by channel segments

located above and below Cow Point. Both segments are justified with the segment below Cow Point having a benefit-to-cost ratio of 1.7:1 and the segment above having a benefit-to-cost ratio of 1.9:1.

4.24 Effect on the Environment.

a. General. Deepening and widening the navigation channel could have the following major environmental effects:

o Reduction in the number of adult Dungeness crabs harvested by the crab fishery at Westport. However, this impact would be avoided or mitigated through dredge equipment modification.

o Disruption of the bottom and temporary removal of bottom-dwelling organisms by initial and annual maintenance dredging.

o Removal of 4 acres of shallow subtidal juvenile salmonid feeding and rearing area. However, this impact would be mitigated through creation of replacement habitat.

o Disruption of the bottom and temporary removal of bottom-dwelling organisms from disposal of dredge material.

o Temporary degradation of water quality.

The existing channel from the outer bar to Cosmopolis now occupies about 800 acres of the approximately 62,000 acres of the estuary below MHHW and approximately 22,400 acres below MLLW, or 1.3 and 3.5 percent of the estuary, respectively. The improved channel would require 1,365 acres (2.2 percent of total estuary below MHHW or 6.1 percent total estuary below MLLW). Populations of bottom-dwelling organisms, including Dungeness crabs, would be reduced by this initial and increased maintenance dredging. Fish and water quality would also be temporarily impacted (see EIS for more detail).

An analysis of hydraulic model data indicates that the density and duration of saltwater intrusion would increase in the ship channel above Hoquiam to Cosmopolis. The effect would be greatest during mean and high freshwater inflows and high tides. The deepening and widening would increase residence time of organic materials upstream of Aberdeen with the potential of adversely affecting water quality. This factor will be offset by enhancement of two-layer flow and by the increased volume of water available to assimilate any oxygen consuming material. Thus, the widening and deepening will have no significant impact upon water quality (Loehr and Collias, 1981). The model tests further indicate that minor changes in current velocities would occur in the vicinity of the navigation channel but changes elsewhere in the estuary would be insignificant.

Effects of ocean disposal of dredge material are not precisely known. Selection of the specific site and method of disposal from hopper dredge or barge would require evaluation of data from additional ocean bottom

studies off Grays Harbor. These studies would be conducted during CP&E. Preliminary effects have been determined from limited studies at Grays Harbor and at other locations such as the Columbia River, Coos Bay, and San Francisco and through the U.S. Army WES Dredged Material and Research Program (DMRP).

Fuel emissions from vehicles and trains associated with waterborne transportation would remain about the same in the project area with or without channel improvements. The channel improvement and bridge modifications would require less bridge openings than without these improvements because of the reduced number of vessel calls.

b. Endangered Species. Four species classified as "endangered" by the U.S. Fish and Wildlife (USDI, 1974) have been sighted at Grays Harbor. These are the brown pelican (*Pelicanus occidentalia californicus*), the Aleutian Canada goose (*Branta canadensis leueopurcia*), the peregrine falcon (*Falco peregrinus*), and the gray whale (*Eschrichtius robustus*). None of these species would be adversely affected by the project (see the EIS for more detail).

4.25 Federal Cost-Sharing Authority. Federal authority to cost share in project improvements and subsequent operation and maintenance is dependent upon congressional authorization of this improvement plan and subsequent implementation funding. Following completion of this feasibility study and subject to approval by higher authority and availability of funds, the Corps of Engineers would continue planning and engineering studies, followed by preparation of detailed plans and specifications, and then construction of the Grays Harbor channel improvements, including replacement of the UPRR bridge. The Federal share of the first cost is estimated at $68,200,000.

4.26 Non-Federal Cost-Sharing Requirements. The Port of Grays Harbor, local sponsor, would be responsible for (1) bearing costs of all port facility improvements and maintenance needed for realization of project benefits, including terminal facilities and berthing areas; (2) acquiring necessary lands, easements, and rights-of-way for project features, including additional aids to navigation and mitigation measures (but not bridge replacement); (3) holding and saving the United States free from damages due to construction works; (4) insuring that affected utilities are relocated; and (5) sharing in the cost of subtidal habitat mitigation measures and assuming the cost of maintaining the replacement habitat. If ultimately wetland and/or upland disposal of dredged material is found to be warranted, then the local sponsor will also be responsible for all associated costs and the securing of disposal sites and constructing necessary disposal containment structures.

4.27 By letter dated 1 March 1982 (appendix B), the Port of Grays Harbor indicated its intent to insure that the requirements of local cooperation for the channel enlargement and mitigation portions of the

project are met, including cost sharing and other actions by nonpor interests. These items of local cooperation are currently estimated to cost about $2,310,000 (October 1981 price level).

4.28 The UPRR Company would be responsible for about $790,000 of the cost of railroad bridge replacement as apportioned according to the principles of the Bridge Alteration Act of 1940, as amended. See appendix D for details of the cost apportionment. Pertinent correspondence with the UPRR is contained in appendix B.

4.29 Under the doctrine of a Federal navigation servitude and conditions of existing Corps of Engineers permits, utility owners would be responsible for relocating affected utilities to accommodate the navigation improvement.

4.30 Non-Federal interests (private timber products companies) benefiting from the project would be responsible for improvements and maintenance needed for realization of project benefits, including terminal facilities and berthing areas.

4.31 The WDOT would be responsible for modifying the existing highway bridge fendering system. Pertinent correspondence with the WDOT is contained in appendix B.

4.32 The apportionment of Federal and non-Federal costs is shown in table 4-3. These estimates include a cost contingency allowance of approximately 20 percent for dredging and 25 percent for other project features, plus an average cost of about 6 percent for engineering and design and 5 percent for supervision and administration for the entire project. Detailed estimates of costs are provided in appendix D.

4.33 Special Studies During Continuation of Planning and Engineering. The following special studies would be conducted during the Continuation of Planning and Engineering phase (CP&E) of the project. The studies would provide information necessary for final selection of dredge disposal sites and refinement of project mitigation measures.

a. Point Chehalis and South Jetty Disposal Areas Circulation Studies. These studies will further evaluate fate of dredged material discharged at the mouth of the estuary. Study results will be used to establish designated disposal sites for material dredged from the estuary (reference appendix D).

b. Refinement of Dungeness Crab Population Estimates. This study will assist in defining the impact of the project on the crab resource. Study results will be used to refine the mitigation proposed for the recommended plan.

c. Dredging Modification to Reduce Dredging-Related Impacts. This study will investigate and test the feasibility of modifying dredges to avoid entrainment of crabs and other fish.

d. Importance of Grays Harbor to the Dungeness Crab Resource of the Pacific Northwest. This study will assist in defining the impact of dredging on the crab fishery. Study results will be used to evaluate potential avoidance and mitigation alternatives.

e. Ocean Disposal Site Designation Studies. These studies will be used to select and formally designate an ocean disposal site(s) for dredged material to be derived from the project.

f. Assessment of Dredging Impact on Lingcod and Other Marine Fish. This study will evaluate the impact of dredging on commercial and recreational fish species, in light of recently obtained life-history information. Study results will be used to determine need for dredge schedule modifications to avoid sensitive areas/seasons.

g. Bowerman Basin Circulation Studies and Endangered Species Monitoring. These studies will evaluate potential disposal of dredged material at Bowerman Basin areas that may be predesignated for dredged material disposal under the Grays Harbor Estuary Management Plan.

SECTION 5. COORDINATION

5.01 Coordination Framework. The goal of the public involvement program for this study has been to keep all interested parties informed of study plans and developments and to solicit input from individuals, interest groups, and agencies to guide plan formulation. Coordination leading to the plan recommended in 1976 is fully described in the 1976 feasibility report. Coordination leading to the plan recommended in this report began in June 1979 when the Seattle District invited representatives of Federal and state agencies to participate in the scoping of environmental studies (see EIS, section 5). This was followed by a public notice in July 1979 announcing resumption of detailed studies for navigation channel improvements in Grays Harbor. Study newsletters were distributed in August 1980, October 1980, May 1981, October 1981, and June 1982; public meetings held 22 January 1981 and 13 July 1982 in Aberdeen; and a public workshop held 2 June 1981 in Aberdeen. The mailing list for distribution of study information contains more than 1,100 names.

5.02 Environmental impacts of the navigation improvement project were analyzed by several independent consultants and the Corps of Engineers following the interagency and public environmental study scoping process which determined the major items of environmental concern. The scoping process and study findings are fully described in the EIS. Concerns relating to water quality, fisheries, and wetland/wildlife impacts have been carefully considered and either avoided or reduced through plan features, including dredge scheduling, selection of dredging equipment, selective use of disposal areas, and replacement of habitat.

5.03 Coordination With Key Agencies.

a. General. As mentioned above, interagency coordination was accomplished throughout the study. Major areas of concern which remain and cannot be fully resolved until further studies are conducted during CP&E include (1) ocean disposal site selection, (2) recirculation of silty material into the harbor from Point Chehalis and South Jetty disposal site use, and (3) crab mortality during dredging. In addition to the Port of Grays Harbor, the U.S. Fish and Wildlife Service (FWS), National Marine Fisheries Service, Environmental Protection Agency (EPA), USCG, WDOT, DNR, the Washington Departments of Ecology (WDE), Fisheries (WDF), and Game (WDG) were key participants in the study. Agency letters and other pertinent coordination correspondence are contained in appendix B.

b. Local Sponsor - Port of Grays Harbor. The Port of Grays Harbor was an active participant during the development of the recommended plan. The port arranged for and conducted coordination and public meetings as well as assembled information for use by the Corps and other agencies.

c. Fish and Wildlife Coordination Act Report. In accordance with the Fish and Wildlife Coordination Act (FWCA) of 1958 (Public Law 85-624), as amended, a final draft FWCA report on this project, dated May 1982, was prepared by the Olympia, Washington, field office of the FWs and provided to the Corps. The FWCA report is attached to this feasibility report/EIS as part of appendix B. The recommendations made by the FWS in the FWCA report are addressed below.

(1) Mitigation.

o We agree that the loss of 4 acres of shallow subtidal habitat in the inner estuary should be replaced because of its limited availability and its importance to juvenile salmonids in inner Grays Harbor. Accordingly, our report recommends acquisition of appropriate mitigation lands.

o We will attempt to reduce Dungeness crab entrainment through dredge modification. If dredge modification is not a feasible way to reduce the number of crabs entrained, the following would be considered: (a) increasing survival of crabs (especially juveniles) already present in the harbor through altering and improving presently available habitat and/or (b) developing means to increase the natural survival of crabs in Grays Harbor. The actual amount of mitigation for crab losses necessary depends upon the significance of the loss to the Grays Harbor population. This significance will be refined through CP&E phase studies.

(2) Continuation of Planning and Engineering Studies.

o We will continue yearly surveys to determine scouring rates at the inner harbor disposal sites. These yearly surveys, which go back to the early 1900's, are the basis for erosion predictions we are presently using (along with the known volume of material deposited from our dredging records). Determining these changes for various times of the year would require additional surveys which are very expensive. The primary scouring forces are the tidal currents which do not significantly change by season, and we do not foresee major seasonal scour rate changes at the estuary mouth. We will sample sediments during CP&E and anticipate that these tests would attempt to determine the direction and magnitude of silt movement from the disposal area. Hopefully, the sampling can coincide with a future maintenance dredging contract. We do not believe that consolidation tests are warranted; sands disposed at the site would consolidate shortly after dumping, while we except silts to remain relatively unconsolidated up to the time they are eroded by tidal currents.

o We agree that the modification of dredging equipment may reduce the number of Dungeness crabs which are entrained by the dredges. We will evaluate the potential of various types of modification for reducing entrainment during the CP&E studies.

o We are considering additional studies on crab distribution and abundance within Grays Harbor during CP&E and will refine our proposed dredging schedule if these studies indicate that such refinement would substantially reduce impacts to Dungeness crabs.

o CP&E studies will be conducted to designate an acceptable ocean disposal site or sites. Some studies are discussed in the project EIS and appendix A which discusses ocean disposal site selection.

Refer to paragraph 4.33 of the feasibility report for a list of special CP&E studies.

(3) Enhancement. The enhancement opportunities proposed by the FWS cannot be recommended by Seattle District because there is no local sponsor for any of the enhancement measures. In addition, perching sites and stream enhancement measures are physically outside the project area and would enhance fish and wildlife habitats which are unrelated to project impacts. However, the second enhancement recommendation in the FWCA report which includes acquisition of and treatment of land in excess of that previously proposed in the recommended plan will be evaluated during CP&E.

We will insure that temporary project construction and maintenance impacts on water quality are kept at an acceptable level by dredging in accordance with the Department of Ecology Water Quality Guidelines for dredging in inner Grays Harbor and lower Chehalis River.

d. Department of Transportation, U.S. Coast Guard. The USCG has the responsibility for installing and maintaining aids to navigation for the Grays Harbor Navigation channel improvement project. During the study, coordination took place with the USCG regarding these aids, with the USCG agreeing to install and maintain navigation aids on the channel as outlined in section 4 (see apendix B for USCG letter).

e. Washington State Department of Transportation. The WDOT owns and operates the State Highway 101 bridge at R.M. 0.1. WDOT was initially concerned that extensive dredging to support a deeper, wider channel would adversely impact the bridge foundation and that the likelihood of ships of larger beam impacting the bridge would increase. As the plan developed and the most efficient waterway depth was determined, it became apparent that most of the existing waterway depth in the vicinity of the highway bridge was greater than the proposed channel and that extensive dredging in the area of the bridge foundation would not be necessary. The Corps of Engineers, the USCG, and pilots agreed that highway bridge fendering would be beneficial and this feature was incorporated into the recommended plan. See appendix B for pertinent correspondence with WDOT.

5.04 Coordination of Draft Report. (Will be completed after public and agency review of the draft report and EIS)

SECTION 6. CONCLUSIONS AND RECOMMENDATIONS

6.01 Conclusions. It is concluded that:

o all practical alternatives have been examined in arriving at a recommended plan;

o significant adverse environmental impacts of the plan have been considered and either avoided or mitigated;

o the proposed action is consistent with national policy, statutes, and administrative directives; and

o the plan best serves the public interest.

6.02 Recommendations. I recommend that the existing project for navigation at Grays Harbor, Washington, be modified to provide improved navigation in accordance with the plan selected herein, with such further modifications thereto as in the discretion of the Chief of Engineers may be advisable and subject to local cost-sharing and financing arrangements which are satisfactory to the President and the Congress; at a first cost to the United States presently estimated at $68,200,000, with increased annual operation and maintenance costs to the United States presently estimated at $2,300,000; provided that, except as otherwise provided in these recommendations, the exact amount of non-Federal contributions shall be determined by the Chief of Engineers prior to project implementation, in accordance with the following requirements which non-Federal interests must agree to prior to implementation:

a. Provide without cost to the United States all lands, easements, and rights-of-way required for construction and subsequent maintenance of the project.

b. Provide suitable sites for upland or confined disposal of initial and/or maintenance dredged material not suitable for open-water disposal.

c. Provide dikes for dredged material disposal if necessary.

d. Accomplish, without cost to the United States, all alterations and relocations as required of buildings, roads, utilities, and other structures and improvements.

e. Hold and save the United States free from damages due to the construction, operation, and maintenance of the project, except for damages due to the fault or negligence of the United States or its contractors.

f. Provide and maintain without cost to the United States berthing areas and local access channels with depths commensurate with depths in the Federal improvements.

g. Based on current cost-sharing policy, provide a cash contribution currently estimated at $11,000 for construction of project mitigation measures, including creation of subtidal habitat replacement, and maintaining these measures.

h. Comply with Sections 210 and 305 of Public Law 91-646, approved 2 January 1971 and entitled the "Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970."

i. Assume a share of the final costs of replacing the Union Pacific Railroad bridge in accordance with the principles of the Bridge Alteration Act of 21 June 1940, as amended, at a presently estimated cost of about $790,000.

______________________	______________________________
Date	NORMAN C. HINTZ Colonel, Corps of Engineers Commanding

DRAFT

ENVIRONMENTAL IMPACT STATEMENT

SUMMARY

1. Major Conclusions and Findings. The National Economic Development (NED), Least Environmentally Damaging (LED) and Recommended (REC) plans consist of widening and deepening the Grays Harbor Navigation Channel from Cosmopolis, Washington, to the Pacific Ocean and replacing the railroad bridge over the Chehalis River in Aberdeen, Washington. Proposed channel dimensions would be similar for all plans and would improve navigation efficiency and safety for water transportation. Mitigation of adverse effects to shallow, subtidal habitat and the Dungeness crab resource is an integral part of each plan.

The NED plan consists of dredging the channel reaches (and disposing of the material) in a manner formulated mainly for cost efficiency. Hopper, pipeline, and clamshell dredges would be used. Most of the material to be dredged would be discharged at disposal sites within the harbor mouth with lesser quantities destined for an ocean disposal site 2-1/2 miles from the harbor mouth and for an upland site in South Aberdeen. Major unavoidable environmental impacts associated with the NED plan include possible recirculation of fines and siltation on vegetated mudflats, possible burial of subtidal population of razor clams, burial of benthos at disposal sites, and removal of channel benthos by dredging. Without mitigation, environmental impacts of the NED plan would include loss of 4 acres of inner harbor juvenile salmonid feeding and rearing area, an estimated reduction of 1.15 to 3.96 percent to the annual Westport Dungeness crab harvest (which ranges from 500,000 to 3,000,000 crabs per year) during initial construction and an estimated maintenance dredging related reduction of the local crab harvest from the existing .84 percent to a new 3.19 percent per year for the life of the project.

The LED plan consists of dredging and disposal in a manner with the least environmental impacts. Clamshell dredges would perform the majority of the work with only the Entrance, and Outer Bar reaches being dredged by hopper dredge. All of the material to be dredged (assuming it is acceptable for open-water disposal) would be discharged at an acceptable ocean disposal site approximately 8 miles from the mouth of the harbor. Without mitigation, environmental impacts associated with the LED plan would include loss of 4 acres of inner harbor juvenile salmonid feeding and rearing area and an estimated reduction of .55 to 1.90 percent to the annual Westport Dungeness crab harvest (500,000 to 3,000,000) during initial construction and an estimated maintenance dredging related reduction to the annual local crab harvest from the existing .84 percent to a new 1.53 percent for the life of the project.

The REC plan consists of dredging and disposal in a manner which considers both economic and environmental factors. Hopper and clamshell dredges would be used. Dredged material (if acceptable for open water disposal) would be disposed at two ocean disposal sites located in the shipping lanes approximately 3-1/2 miles from the mouth of the harbor,

and at two deep water disposal areas, Pt. Chehalis and S. Jetty, near the mouth of the estuary. The fine grain size material will be discharged at South Jetty and in the ocean. Therefore, resuspension of fines and subsequent increased siltation within the estuary would be minimal and avoided under this plan. Under the REC plan, total investment cost of the project would be $71,300,000 with a benefit-to-cost ratio of 1.7 to 1.0. Without mitigation, environmental impacts associated with the REC plan would include loss of 4 acres of inner harbor juvenile salmonid feeding and rearing area, an estimated reduction of .92 to 3.17 percent to the annual Westport Dungeness crab harvest during initial construction and, after construction, an estimated maintenance dredging-related increased reduction from the existing .84 percent to a new 2.55 percent to the annual local crab harvest for the life of the project.

Impacts associated with each of the project plans without mitigation, as previously discussed, are expected to be replaced or avoided by the proposed mitigation plan. The mitigation for each of the plans would consist of replacement of 4 acres of juvenile salmonid feeding and rearing area and either schedule or equipment modifications to reduce crab mortality.

2. Resolutions During Feasibility Planning. Questions concerning the environmental impacts which would be associated with the widening and deepening of the navigation channel prompted several studies of the physical, chemical, and biological environment of the harbor. The major issues involved impacts on water quality, fish distribution, fish and crab entrainment during dredging, and location of dredged material disposal sites. Based on the study reports, long-term water quality impacts associated with the project will be minimal, dredging schedules have been established to avoid periods of maximum concentrations of juvenile salmonids in the innermost reaches of the harbor, and few, if any, juvenile salmonids will be entrained by the dredges. In addition, crab entrainment and indirect impacts have been reduced through scheduling dredging to avoid months of maximum crab abundance in various channel reaches and by avoiding disposal of silts in the harbor mouth during months of maximum crab larvae abundance. In-harbor disposal sites have been selected for their capacity (approximately 2 million cubic yards (c.y.) each per year), for the scouring action present at these sites, and for cost effectiveness. Dredged material discharged at these sites is also expected to partially replace the material presently scoured away from South Jetty by tidal action, therefore partially alleviating the ongoing undermining of the jetty. This scouring will sweep the dredged material disposed at these sites from the harbor. The ocean disposal sites have been tentatively located in the shipping lanes 3-1/2 miles from Grays Harbor for purposes of estimating the costs of the proposed project. Several studies indicate that little material discharged at these sites will return to either the harbor or the ocean beaches. However, the biological impacts associated with using these sites will not be thoroughly evaluated until proposed continuation of

planning and engineering (CP&E) phase studies associated with the project have been completed. Bioassay and bioaccumulation tests are presently being conducted to evaluate the impact of Grays Harbor sediment and water associated with it on aquatic organisms. A supplemental information package containing the bioassay testing results will follow the distribution of this document since the studies will be completed during the public review process. Chemical and bioassay tests performed to date do not indicate a toxicity or accumulation potential from the low concentrations of contaminants associated with the sediments to be dredged.

Pursuant to Section 404(r) of the Clean Water Act, upon submittal of a 404(b)(1) evaluation with this environmental impact statement and approval by Congress, no further action by the Corps of Engineers to meet the requirements of Sections 301, 402, or 404 of the Clean Water Act will be necessary.

3. Relationship to Environmental Requirements. The relationship of the Grays Harbor Navigation Channel Improvements Project to environmental requirements is summarized in the following table:

TABLE EIS i-1 (con.)

STATE AND LOCAL POLICIES	No Action	Alt. 2a	Alt. 2b	Alt. 2c
Washington State Constitution				
Article XV. Harbors and Tide Waters	Full	Partial 1/	Partial 1/	Partial 1/
Article XVII. Tidelands	Full	Full	Full	Full
Multiple Use Concept in Management and Administration of State Owned Lands (RCW 79.68.060)	Full	Full	Full	Full
State Environmental Policy Act of 1971 (RCW 43.21)	Full	Partial 1/	Partial 1/	Partial 1/
Water Resources Act of 1971 (RCW 90.54)	N/A	N/A	N/A	N/A
Shoreline Management Act of 1971 (RCW 90.58) and Grays Harbor County Shoreline Management Program	Full	Partial 1/	Partial 1/	Partial 1/
Water Pollution Control Act (RCW 90.48)	Full	Partial 1/	Partial 1/	Partial 1/
Permits Required:				
Shoreline Substantial Development Permit	No	No	No	No
Shoreline Conditional Use Permit	No	No	No	No
Washington Department of Natural Resources Lease of Tidelands	No	No	No	No
Washington Department of Ecology Water Quality Certification	No	Alt. 2a-2c: Exemption pursuant to Section 404(r) of the Clean Water Act is being sought during congressional authorization.		

NOTES: The compliance categories used in this table were assigned based on the following definitions:

a. Full Compliance - All the requirements of the statute, executive order, and related regulations have been met.

b. Partial Compliance - Some requirements of the statute, executive order, or other policy and related regulations remain to be met.

c. Noncompliance - None of the requirements of the statute, executive order, or other policy and related regulations have been met.

d. Not Applicable (N/A) - Statute, executive order, or other policy not applicable.

1/Full compliance with completion of the final EIS.
2/Full compliance upon completion of CP&E studies.
3/Full compliance with congressional authorization.

TABLE EIS 1-1

Relationship of Plans to Environmental Protection Statutes and Other Environmental Requirements for Alternatives to Grays Harbor and Chehalis and Hoquiam, Washington, Rivers Channel Improvements for Navigation

FEDERAL STATUTES	No Action	NED Alt. 2a	LED Alt. 2b	REC Alt. 2c
Archeological and Historic Preservation Act, as amended, 16 USC 469 et seq.	Full	Partial[1]	Partial[1]	Partial[1]
Clean Air Act, as amended, 42 USC 1857h-7 et seq.	Full	Full	Full	Full
Clean Water Act, as amended (Federal Water Pollution Control Act), 33 USC 1251 et seq.	Full	Partial[3]	Partial[3]	Partial[3]
Coastal Zone Management Act, as amended, 16 USC 1451 et seq.	Full	Partial[1]	Partial[1]	Partial[1]
Endangered Species Act, as amended, 16 USC 1531 et seq.	Full	Full	Full	Full
Estuary Protection Act 16 USC 1221 et seq.	Full	Full	Full	Full
Federal Water Project Recreation Act, as amended, 16 USC 460-1(12) et seq.	Full	Full	Full	Full
Water Resources Act, 1976, Section 150	Partial[1]	Partial[1]	Partial[1]	Partial[1]
Fish and Wildlife Coordination Act, as amended, USC 661 et seq.	Full	Partial[1]	Partial[1]	Partial[1]
Land and Water Conservation Fund Act, as amended, 16 USC 4601-4601-11 et seq.	Full	Full	Full	Full
Marine Protection Research and Sanctuaries Act, 33 USC 1401 et seq.	Full	Partial[2]	Partial[2]	Partial[2]
National Environmental Policy Act, as amended, 42 USC 4321 et seq.	Full	Partial[2]	Partial[2]	Partial[2]
Rivers and Harbors Act, 33 USC 403 et seq.	Full	Partial[1]	Partial[1]	Partial[1]
Watershed Protection and Flood Prevention Act, 16 USC et seq.	N/A	N/A	N/A	N/A
National Historic Preservation Act, 16 USC 407a et seq.	Full	Full	Full	Full
Wild and Scenic Rivers Act, as amended, 16 USC 1271 et seq.	N/A	N/A	N/A	N/A
Executive Orders, Memoranda:				
Flood Plain Management 11988	Full	Full	Full	Full
Protection of Wetlands 11990	Full	Full	Full	Full
Environmental Effects Abroad of Major Federal Actions 12114	N/A	N/A	N/A	N/A
Executive Memorandum Analysis of Impacts on Prime and Unique Farmlands in EIS, CEQ Memorandum, 30 August 1976	N/A	N/A	N/A	N/A

DRAFT
ENVIRONMENTAL IMPACT STATEMENT

GRAYS HARBOR AND CHEHALIS AND HOQUIAM RIVERS, WASHINGTON
CHANNEL IMPROVEMENTS FOR NAVIGATION

TABLE OF CONTENTS

TABLE OF CONTENTS (con.)

TABLE OF CONTENTS (con.)

TABLE OF CONTENTS (con.)

TABLE OF CONTENTS (con.)

FIGURES

TABLES

TABLE OF CONTENTS (con.)

AD-A115 779 CORPS OF ENGINEERS SEATTLE WA SEATTLE DISTRICT F/G 13/2
INTERIM FEASIBILITY REPORT AND DRAFT ENVIRONMENTAL IMPACT STATE--ETC(U)
JUN 82

UNCLASSIFIED NL

2 OF 6
AD A
115 779

DRAFT

ENVIRONMENTAL IMPACT STATEMENT

GRAYS HARBOR AND CHEHALIS AND HOQUIAM RIVERS, WASHINGTON
CHANNEL IMPROVEMENTS FOR NAGIVATION

SECTION 1. NEED FOR AND OBJECTIVES OF ACTION

1.01 Study Authority. This environmental impact statement (EIS) is submitted in partial response to resolutions of the committee on Public Works of the U.S. Senate and House of Representatives dated 21 October and 30 December 1957. Refer to feasibility report paragraph 1.01 for further detail.

1.02 Public Concerns and Planning Objectives. The Grays Harbor region (figure EIS 1-1) has long been economically dependent on logging and export of forest products and is now a major west coast port for transportation of wood products to foreign nations. The present authorized 30-foot-deep waterways and the horizontal clearance of the Union Pacific Railroad (UPRR) bridge at Aberdeen are inadequate to accommodate the present and future deep-draft vessels with drafts up to 37 feet and beams in excess of 100 feet. The current channel size limits the large vessels (i.e., 34-foot draft) to calling on Grays Harbor only during favorable tide and weather conditions, and in addition, these vessels must "light load" or carry less than their maximum load. Accordingly, smaller vessels with greater transportation costs are being used.

The planning objective for this study was to improve the efficiency and safety of deep-draft water transporation.

In formulating a plan to achieve the above goals, a wide range of alternatives were considered and the resultant effects of each proposed alternative were evaluated in terms of economic, environmental, and social factors. The criteria used in the evaluation are detailed in section 2 of the feasibility report.

1.03 Background. In July 1976, Seattle District, U.S. Army Corps of Engineers, completed a feasibility report and revised draft EIS for subject study at Grays Harbor, Washington. The proposed action consisted of widening and deepening the existing authorized navigation channel in Grays Harbor. Initial construction would have involved widening and deepening the existing channel, disposal of approximately 19.3 million cubic yards (c.y.) of material, and operation and maintenance of the channel for 50 years. Dredged material would have been discharged at a 60-foot contour site in the ocean, at a South Jetty site, and at diked uplands upriver of Aberdeen. Also included in the previously proposed plan was reconstruction of the UPRR bridge across the Chehalis River at Aberdeen.

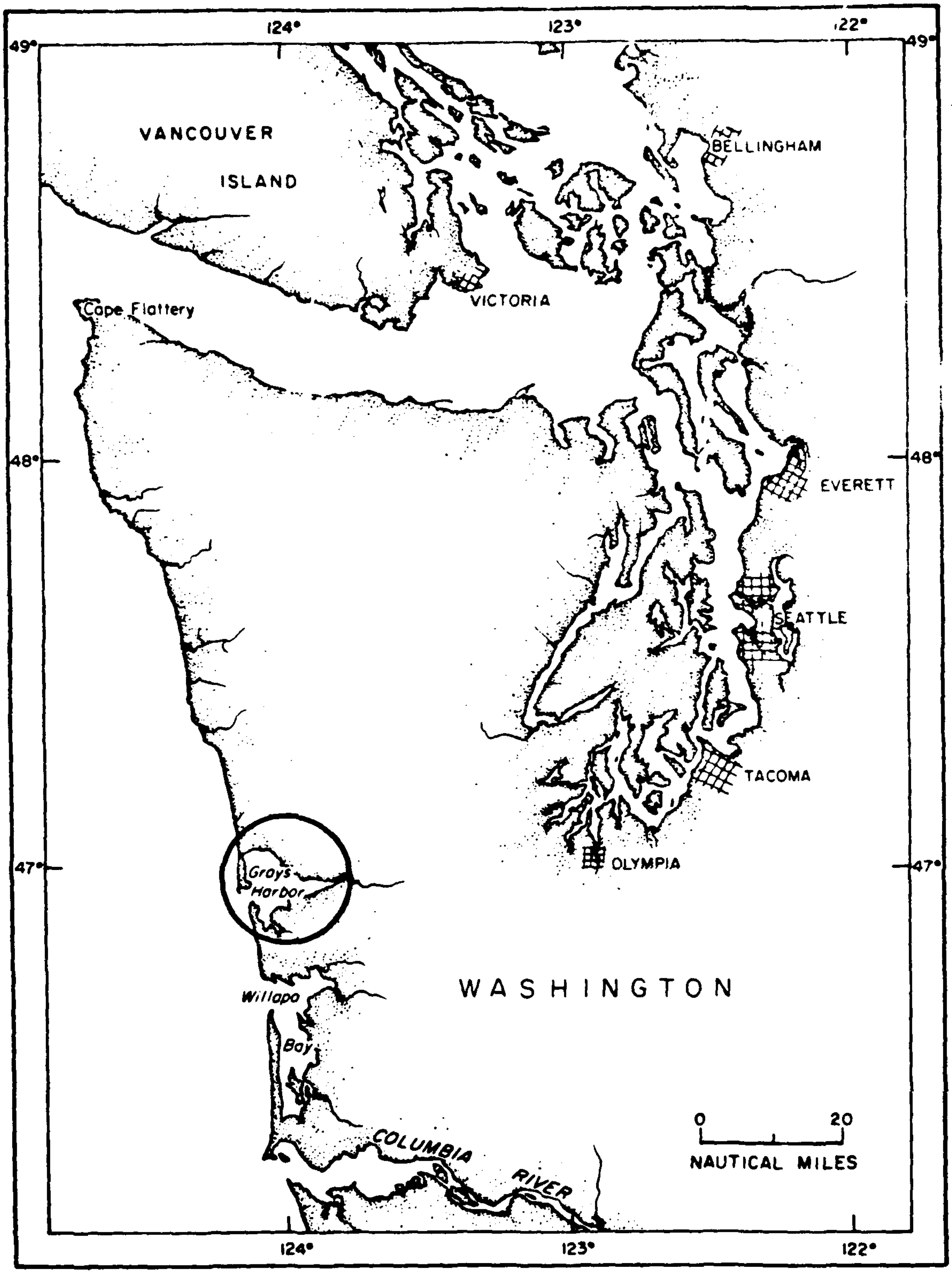


Figure EIS1-1 Location of Grays Harbor

By letter dated 15 March 1979, Office of Management and Budget returned the documents to the Secretary of the Army requesting that additional studies be undertaken to resolve concerns relating to economic evaluation, design criteria, and environmental impacts. Subsequently, the feasibility report and EIS were returned to Seattle District for revision. Prior to initiating the additional studies, Seattle District prepared a plan of study (POS). A major component of the POS was an interagency scoping effort of environmental studies deemed necessary to evaluate a recommendation for construction of the project. This scoping effort is described in section 5 of the EIS.

The environmental studies provided important additional information needed for an accurate evaluation of the environmental consequences associated with the proposed project and are listed in table EIS 4-1.

1.04 Grays Harbor Navigation Channel.

a. History. Navigation improvements were initially authorized by the Rivers and Harbors Act of 3 June 1896 to prevent the continuous shifting of the entrance channel, bar, and bottom which deterred regular entry of ships into Grays Harbor. Settlement of the area set the pattern for the present economy and the need for improvements to facilitate shipping (Grays Harbor Dredging Effects Study (GHDES), 1976). The entrance bar and channel were stabilized in the early 1900's by the construction of a jetty system and dredged channels. Subsequent reconstructions, improvements, and expansions have culminated in the extensive jetty, groin, and dredged channel system present today.

b. Existing Project. The Grays Harbor navigation channel is presently maintained at -30 feet mean lower low water (MLLW) by annual dredging of bottom material shoals in various areas from Cosmopolis through South reach, and the Entrance reach and bar are self maintaining as a result of the jetty system. Dredged material from Grays Harbor is currently being discharged at the existing Department of Natural Resources (DNR) designated Point Chehalis open-water disposal site (see plate 7).

c. Proposed Project. The Federal responsibilities of the proposed navigation channel improvement project would include initial widening and deepening and maintenance of the existing channel from Cosmopolis, Washington, to the Pacific Ocean. Disposal of dredged material would occur in the harbor mouth and in the ocean (and at an upland site if any of the sediment is unacceptable for open-water disposal). The UPRR bridge in Aberdeen would be replaced with a 250-foot-horizontal channel clearance bridge and would be cost shared between the bridge owner and the Federal government. The local sponsor, the Port of Grays Harbor, would provide all lands required for channel enlargement, dredged material disposal, utility relocations, and in addition, would dredge port vessel berthing areas to depths commensurate with the enlarged channel. Mitigation required for this project is replacement of 4 acres of shallow subtidal habitat and schedule and equipment modification to reduce crab mortality associated with dredging.

SECTION 2. ALTERNATIVES

2.01 Preliminary Alternatives Eliminated from Study. Several alternatives have been considered to meet the need for navigation improvements in Grays Harbor. Possible solutions that have been eliminated from further study are listed below. Reference paragraph 3.03 in the feasibility report for a detailed discussion of these preliminary alternatives.

- o Lightering
- o Waterfront Renewal
- o Development of Other Grays Harbor Sites
- o Development of Other West Coast Ports

2.02 Final Alternatives. The final array of alternatives considered in detailed planning are described in the following sections. Tables EIS 2-1 and EIS 2-2 summarize the engineering features of the alternative plans. Included in this text are the no-action alternative and three variations to the channel improvements alternative (National Economic Development (NED), Least Environmentally Damaging (LED), and Recommended (REC) plans). The impacts of each alternative are summarized in paragraph 2.04 and a detailed description of impacts is presented in EIS section 4.

a. Alternative 1: Continue Existing Conditions (No Action). Under the no-action plan the project area would be maintained under the following existing conditions:

o Channel depth maintained at present authorized depth of -30 feet MLLW.

o Larger ships would be forced to sail with partial loads.

o The UPRR bridge at Aberdeen would not be replaced and larger ships would still be unable to transport goods upstream of the bridge.

With these existing conditions and the trend continuing toward larger ships, vessels will not be used efficiently and, thus, higher shipping costs will result under the no-action plan. Shippers will be likely to seek other, more efficient deep-draft ports. Long-term forest product exports from Grays Harbor are expected to decrease as a final result of the no-action plan. Development is not likely to increase under these conditions. Therefore, the no-action plan is not being recommended.

With the present channel conditions and anticipated slow growth for industrial and commercial development, important biological parameters and resources such as commercial crab fishery, recreational clamming,

TABLE EIS 2-1

EXISTING[1] AND PROPOSED DIMENSIONS, QUANTITIES TO BE DREDGED, AND AREA DISTURBED BY DREDGE FOR ALTERNATIVES 2a-2c

Reach	Length (miles)	Channel Dimensions (feet)	Channel[2] Initial Cut Vol. & Maintenance (1,000 c.y.)	Turning Basin[2] Size and Quantity (feet (1,000 c.y.))	Total Area Disturbed by Proposed W&D: Bottom Channel (Acres)	Channel Side Slopes (Acres)	Shallow Subtidal (Acres)	Total New Disturbance
South Aberdeen	2.3	[200 x 30] 250 x 36	1,300 (100)[3]	[550 x 1,000 x 30] 750 x 750 x 30 (150)[3]	88	17	2	
Aberdeen	1.5	[200 x 30] 250 x 36	550 (50)		60	25	--	
Cow Point	0.7	[350 x 30] 350 x 38	700 (200)	[600 x 1,000 x 30] 1,000 x 1,000 x 38 (300)	40	11	2	
Hoquiam	3.5	[350 x 30] 350 x 38	2,150 (100)	750 x 750 x 30 (150)	125	25	--	
Moon Island	2.8	[350 x 30] 350 x 38	1,900 (200)		120	20	--	
Cross-Over	3.4	[350 x 30] 400 x 38	2,900 (450)		165	20	--	
South	3.5	[350 x 30] 400 x 38	3,400 (450)		170	35	--	
Entrance Channel	4.0	[350 x 30] 1,000 x 46-38	200 (0)		20	2	--	
Outer Bar	2.5	[600 x 30] 1,000 x 46	4,000 (800)		290	50	--	
Total	24.2		17,100	600	1,078	205	4	565 Acres
Existing Total					724 (Bottom & Side Slope)			

1/Existing or no-action (alternative 1) dimensions are indicated in brackets.
2/Includes quantities for 2-foot construction contract overdredge and 2-foot advanced maintenance and in parenthesis quantities for maintenance dredging.
3/Future approximate O&M dredging quantities per year are indicated in parenthesis.

ENGINEERING FEATURES OF ALTERNATIVES 1 and 2a-2c

Feature	Alternative 1 (No Action)	Alternative 2c (REC Plan)	Alternative 2a (NED Plan)	Alternative 2b (LED Plan)
Present Navigation Channel	Continue maintenance dredging to existing authorized dimensions.	Widen and deepen entire channel to Cosmopolis, construct turning basin at South Aberdeen and Hoquiam, and widen and deepen at Cow Point.	Same as REC	Same as REC
Wetland and Shallow Subtidal Habitat Removal	None	Removal of 2 acres at South Aberdeen (-10 to +8 MLLW); Removal of 2 acres at Cow Point (-5 to +8 MLLW).	Same as REC	Same as REC
Presently Undisturbed Habitat Converted to New Disturbed Channel Habitat	None	565 acres	Same as REC	Same as REC
Open Water Sites For Dredge Material Disposal	Point Chehalis	9.9 mil. c.y. to open water at South Jetty/Point Chehalis and 7.1 mil. c.y. to sites 3 1/2 miles from the harbor mouth.	11.55 mil. c.y. to open water at Point Chehalis/South Jetty, 5.55 mil. c.y. to ocean (2-1/2 miles from harbor mouth).	16.1 mil. c.y. to ocean (8 miles from harbor mouth).
Upland Disposal of Dredged Material	None	*1 million c.y. at confined upland log storage.	1 mil. c.y. at confined upland log storage.	*1 mil. c.y. at confined upland log storage.
Union Pacific Railroad Bridge	No change	Replace and increase horizontal clearance	Replace and increase horizontal clearance	Replace and increase horizontal clearance
Shipping	Increased shipping costs.	Increased safety, reduced cost, increased commodity movement.	Increased safety, reduced cost, increased commodity movement.	Increased safety, reduced cost, increased commodity movement.
Land Use	Continued current growth trends.	Potential for increased growth.	Potential for increased growth.	Potential for increased growth.
Employment and Economic Growth	Employment trend remains same, possible decrease.	Temporary increase during construction.	Temporary increase during construction.	Temporary increase during construction.
Noise	No significant change; could increase or decrease.	Temporary increase due to construction; same as No Action.	Temporary increase due to construction; same as No Action.	Temporary increase due to construction; same as No Action.
Net Benefits to Public Consumer	No change; possible decrease.	Increase	Increase	Will not increase.

*Only used if material is unacceptable for open water disposal.

salmon migration, benthic invertebrates, wetlands, water quality, and endangered species would not be expected to suffer substantial increases in impacts above and beyond the existing operation and maintenance (O&M) impacts.

b. Alternative 2a: National Economic Development (NED) Plan.

(1) Engineering Features. The authorized Federal channel for the Grays Harbor waterway would be widened and deepened to dimensions which are summarized in table EIS 2-1 and in table 3-2 of the feasibility report. The benefit-to-cost ratio for the alternative 2a, including initial and maintenance dredging, would be 1.9 to 1.0.

(a) Initial Construction. Project construction would take 2 years or less. Three turning basins are proposed: at Cow Point, South Aberdeen, and Hoquiam reaches. In addition, the 125-foot-horizontal clearance UPRR bridge at Aberdeen would be replaced by a bridge with a 250-foot-horizontal channel clearance. Dredging would be performed with hopper, clamshell, and pipeline dredges.
Four sites would be used for disposal of 17.1 million c.y. of dredged material:

- Fifty-one-acre upland site in South Aberdeen (1 million c.y.).
- A new Point Chehalis open-water disposal site in the Grays Harbor estuary (5,375,000 c.y.).
- South Jetty, an open-water disposal site at the mouth of Grays Harbor (6,175,000 c.y.).
- Sixty-foot contour in the ocean located approximately 2.5 miles west from the mouth of Grays Harbor (4,550,000 c.y.).

Disposal sites are located on plate 7 and detailed on plate 3.

(b) Operation and Maintenance. Channel depths would be maintained by using a hopper dredge for the outer reaches (outer bar upstream to, and including, one third of Moon Island) and using clamshell for reaches upstream of South reach to dredge approximately 2.35 million c.y. per year. The sandy outer bar material would be discharged in the ocean at a 2.5-mile disposal site and all other dredged material would be discharged at the new Point Chehalis and South Jetty sites.

(2) Environmental Features. This alternative has incorporated the use of clamshell dredges which is the most cost-effective dredge for construction of reaches upstream of Moon Island. The clamshell would reduce Dungeness crab entrainment and possible resuspension of contaminants at the dredging site more effectively than hopper dredging. Cost effectiveness dictates that hopper dredging be used from the Moon Island reach to and including the outer bar.

Of the plans considered in detail, the NED plan would have the greatest adverse environmental impacts. Under this plan, 67 percent (11,550,000 c.y.) of 17.1 million c.y. of dredged material is proposed for estuarine open-water disposal which includes the largest percentage of fines for any plan. If this large amount of material is discharged in the estuary, the potential exists for impacting eelgrass beds and mudflats through recirculation and subsequent sedimentation of fines. These eelgrass beds and diatom-rich mudflats provide valuable food and habitat for black brant, Dungeness crabs, and fish. The potential exists for recirculation of suspended sediment and sediment-associated contaminants to the estuary.

Table EIS [illegible] shows the percentage of sand, sandy silt, silt, and gravel that would be discharged at each disposal site under alternatives 2a-2c. Table EIS 2-4 summarizes the months during which dredging would occur for alternatives 2a-2c and the composition of material to be dredged from each reach.

(3) Mitigation and Monitoring. The NED plan would have the greatest environmental impacts of any of the three alternative plans. Although [illegible] reduced some project impacts [illegible] for the REC plan (paragraph 4.02), the type of dredge to be used [illegible] disposal locations and associated activities have been selected [illegible] cost efficiency [illegible] than for environmental considerations.

The significant adverse impacts associated with the NED plan [illegible] potential impacts on outmigrating juvenile salmonids [illegible] its degradation and potential impacts are greater [illegible] outer harbor biological resources associated with the disposal [illegible] majority of the dredged material [illegible] in-harbor disposal [illegible] reduce the impacts to the Dungeness crab resource [illegible] juvenile salmonid habitat would be included in the NED plan [illegible] refined through Continuation of Planning and [illegible] as discussed in paragraph 4.03g. The mitigation for [illegible] would be similar to that discussed for the REC Plan. However, should the mitigation effort to avoid losses to crabs be unsuccessful, a substantially larger effort than the REC Plan would be required for the [illegible] to restore the crab population to Grays Harbor through an effort to increase natural survival.

Mitigation to replace the 4 acres of shallow subtidal juvenile salmonid feeding and rearing habitat, and to insure that adequate water quality for fish is maintained during project construction, will be the same as described in paragraph 4.03g for the REC plan. In addition, monitoring at the ocean disposal site and chemical analysis of channel sediments will be required as discussed for the Recommended Plan.

TABLE 2-3
PERCENT COMPOSITION OF MATERIAL TO BE DISCHARGED
AT DISPOSAL SITES DURING INITIAL CONSTRUCTION

NED	Pt. Chehalis	S. Jetty	Ocean (2-1/2 mile)	Upland (51 acres)
Total yardage (c.y.)	5,375,000	6,175,000	4,550,000	1,000,000
Type of Material (Percent)				
Sand	32	31	88	
Sandy silt1/	64	56	12	100
Silt	0	13	0	
Gravel	4	0	0	

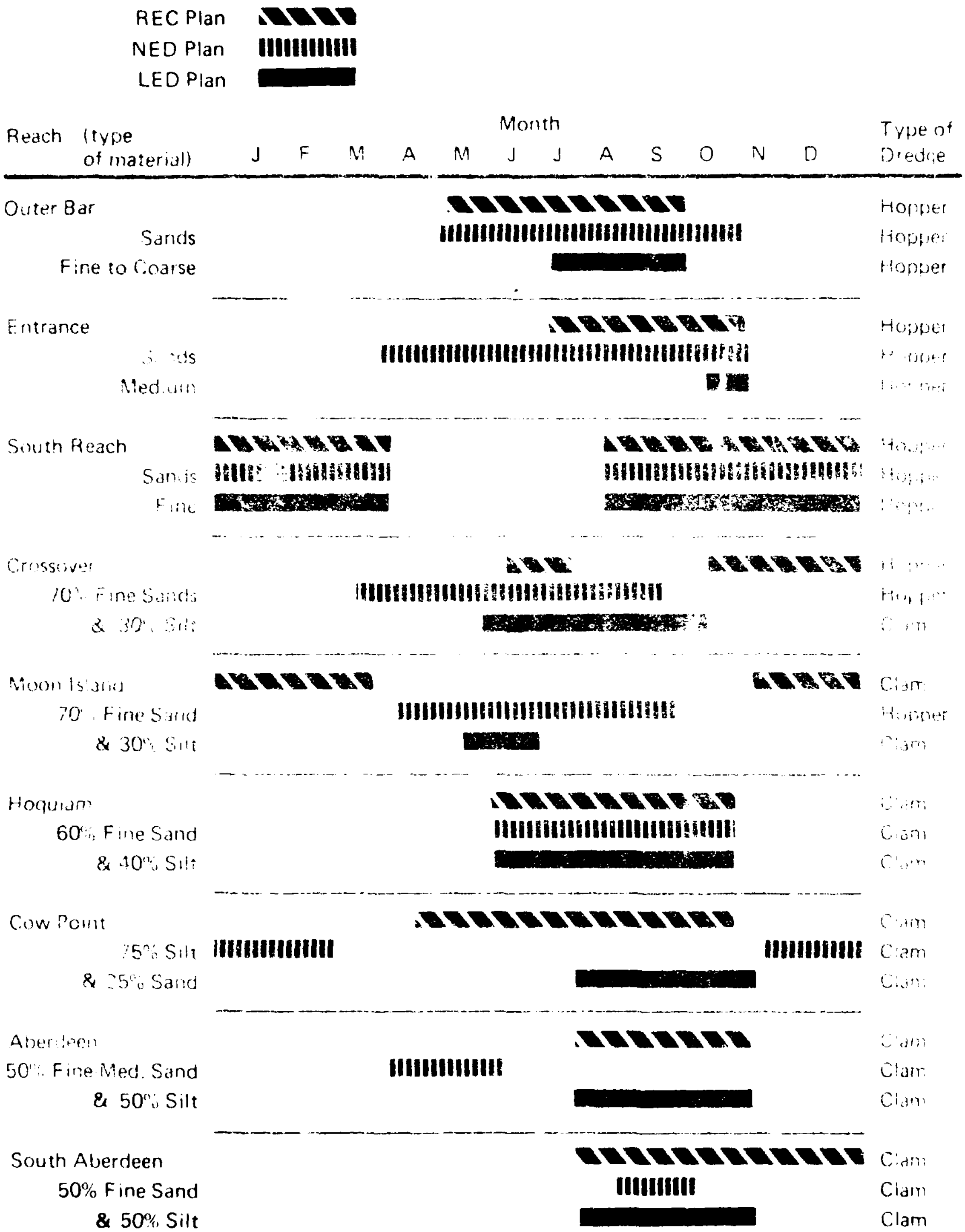
LED	Pt. Chehalis	S. Jetty	Ocean (8-mile)	Upland
Total yardage (c.y.)	0	0	16,100,0002/	0
Type of Material (Percent)				
Sand			41	
Sandy silt			43	
Silt			3	
Silty sand			12	
Gravel			1	

REC	Pt. Chehalis	S. Jetty	Ocean (3-1/2 mile)	Upland
Total yardage (c.y.)	4,300,000	5,600,000	7,200,000	0
Type of Material (Percent)				
Sand	95	43	56	
Silty sand1/	0	34	6	
Sandy silt2/	0	23	38	
Gravel	5	0	0	

1/Refer to plate 10 for approximate percentages of sand and silt in each reach and table A-1 (appendix A) for quantity of material from each reach to be discharged.

2/This total does not include 1 million c.y. of redredged material which are included in NED and REC plans.

TABLE EIS 2-4
MONTHS DURING WHICH DREDGING COULD OCCUR



c. Alternative 2b: Least Environmentally Damaging (LED) Plan.

(1) Engineering Features.

(a) Initial Construction. The channel design and bridge replacement design of this plan are the same as those described under the NED plan. The major engineering differences between this plan and the NED plan are (1) the location of disposal sites, (2) the dredging schedule, and (3) dredge types to be used. This LED plan proposes disposal of all dredged material in the ocean at a site to be located within 8 miles of Grays Harbor.

Project construction for alternative 2b would take 3 years or less. Table EIS 2-3 summarizes the months during which dredging would occur. Under this plan, clamshell dredges would be used in all reaches upstream of the Entrance reach (South reach - South Aberdeen reach) for construction dredging.

(b) Operation and Maintenance. The O&M for the LED plan includes using the hopper for the Outer Bar reach and clamshell for all other reaches. All maintenance dredged material (2.35 million c.y./year) will be discharged in the ocean at a disposal site located within 8 miles of the harbor mouth.

The benefit-to-cost ratio for initial and maintenance dredging is 0.99 to 1.0.

(2) Environmental Features. The LED construction and O&M plan has been designed to lessen, where practicable, the impacts on the environment. Of major concern in the design and planning of this alternative was the general biological importance of the estuary, the migration of salmonids, the overall abundance and movement (migration) of Dungeness crabs into and out of the estuary, water quality, and the distribution of razor clams on nearby ocean beaches. The clamshell dredge was chosen to perform dredging upstream of South reach to lessen impacts to fish, crabs, and water quality. All the dredged material would be discharged at an open ocean site within 8 miles of Grays Harbor (see paragraph 2.03) to avoid any adverse impacts associated with discharging dredged material in the estuary.

(3) Mitigation and Monitoring. The LED plan would have the least environmental impacts of the three alternative channel improvement plans. Planning and resource agency coordination for the LED plan have reduced overall project impacts below those described for the recommended plan (paragraph 4.02d(3)). Use of clamshell dredges with ocean disposal, as well as dredging schedule modifications, would offer crabs and fish the most protection from adverse environmental conditions and entrainment. Further impact reductions could possibly be achieved after evaluation of CP&E studies.

The mitigation for this plan would be similar to, but substantially less than, the mitigation discussed for these impacts for the Recommended Plan since a hopper dredge would only be used in the Entrance and Outer Bar reaches under the LED plan.

Mitigation to replace the 4 acres of shallow subtidal habitat lost, and to insure that adequate water quality for fish is maintained during project construction, will be the same as described in paragraph [illegible] for the Recommended Plan. In addition, monitoring at the ocean disposal site and chemical analysis of channel sediments will be required as discussed for the Recommended Plan.

d. Alternative 2c: Recommended (REC) Plan. The recommended channel improvement plan is a compromise and blending of the two previous alternatives 2a and 2b taking into consideration both cost efficiency and environmental concerns. Rationale for plan selection and primary features of the REC plan are presented in the following paragraphs.

The recommended channel improvements plan for Grays Harbor involves widening and deepening the existing Federal channel. Channel improvements from the Outer Bar to the Aberdeen-Cosmopolis area would make waterborne commerce more efficient through savings in shipment costs and reduction of tidal delays. The widening and deepening of the channel has, therefore, been selected as the best alternative to meet the need for port expansion in Grays Harbor.

The REC plan for channel improvements has taken into consideration both cost efficiency and environmental concerns and has been selected because it is an effective compromise and integration of the LED and NED plans. The REC plan has substantially reduced the unavoidable losses in the estuary and crab losses that would be incurred under the NED plan. This has been accomplished through modification of dredge type, dredge schedule, type of material to be discharged and disposal locations proposed for REC. In addition, this plan represents a substantial reduction in cost over the LED while still maintaining an acceptable level of environmental protection.

(1) Engineering Features.

(a) Initial Construction. The authorized Federal channel for Grays Harbor would be widened and deepened to the same dimensions as the NED and LED plan in a 2-year construction period. Dimensions for the channel are summarized in table EIS 2-1 and plate 1. The proposed channel dimensions are considered safer than the present dimensions and sufficient for passage of larger vessels.

Three turning basins would be constructed. Hoquiam and south Aberdeen would be new turning basins and the third turning basin, already existing at Cow Point, will be widened and deepened. Refer to table EIS 2-1 for turning basin dimensions. The Hoquiam turning basin has been added to provide turning space for empty vessels in the vicinity of downstream shipping facilities, thus reducing upstream traffic and shipping costs. In addition, the 125-foot-horizontal clearance UPRR bridge in Aberdeen would be replaced by a bridge with a 250-foot-horizontal clearance and realined to the proposed channel.

Approximately 17.1 million c.y. of dredged material would be discharged in four designated open-water disposal sites: new Point Chehalis, South Jetty, and two in the ocean at a radius of 3-1/2 miles from the harbor mouth. In the event that the bioassay tests indicate some dredged material is unacceptable for open-water disposal, then a designated 51-acre upland disposal area (currently a log storage site) would be used for disposal of up to 1 million c.y. of dredged material. Two ocean disposal sites are presently proposed. The two sites are in different towboat lanes 3-1/2 miles from Grays Harbor at the 100-foot contour. One site, due west of the harbor, will be used for disposal of silty material while the second site, southwest of the harbor, will be used primarily for disposal of sands. The second ocean disposal site has been chosen due to the close proximity to the Outer Bar reach. Plate 7 shows the proposed ocean disposal sites. Resource agencies have agreed that potential ocean sites do exist within 8 miles from the entrance to Grays Harbor. An ocean site is needed for disposal of silts. The 3-1/2-mile disposal site has been proposed (1) because it is the nearest silt site for disposal of like on like material and (2) for purposes of cost analysis for the feasibility report. Biological, physical, and chemical tests will be conducted at several potential ocean disposal sites between 2.5 and 8 miles of the harbor during the CP&E phase of this project to determine the most acceptable ocean disposal locations.

The South Jetty and Point Chehalis disposal areas have an estimated one time volume capacity of approximately 1.5-2 million c.y. each. The South Jetty site consists of one 900-foot-radius disposal site while the Point Chehalis disposal areas would be composed of two 900-foot-radius standard size DNR sites (plate 3). The center of the Point Chehalis sites will be located 1/4-mile and 6/10-mile southwest of the existing Point Chehalis site. The volume capacity of South Jetty and Point Chehalis disposal areas has been estimated using the formula πr^2(1ft) where r = 900 feet. Therefore, approximately 100,000 c.y. would cover a 900-foot-radius site approximately 1-foot deep. This approximation of the volume capacity does not take into consideration the scouring action or the spreading of the material after discharge, thus new Point Chehalis and South Jetty sites are expected to have a greater capacity than estimated by the formula.

A final decision on the location of the disposal site or sites will be based on an evaluation of the results of post feasibility studies.

(b) Operation and Maintenance. O&M for the Recommended Pla.. is a 50-year project. It includes hopper dredging the outer reaches (Outer Bar to and possibly including the western end of Moon Island) and clamshell dredging all other reaches. However, a hopper dredge may be used for all O&M should it prove to be more cost efficien . Clamshell and hopper dredges are currentl· used for O&M of the existing project. Although the proposed O&M (2.35 million c.y.) is an 88 percent increase above the existing project, two-thirds of the increase! dredged material will be dredged from the outer bar.

Coarser dredged materia would be discharged at new Point Chehalis with finer material discharged at South Jetty. New Point Chehalis would also be retained as a backup site if South Jetty becomes inaccessible due to adverse weather or sea conditions. The sandy outer bar material would be discharged at the ne rest 3.5-mile ocean disposal site.

The proposed frequency . O&M dredging is the same as the existing O&M (see table 3-2 in the ·asibility report). Inner harbor reaches (Moon Island upstream) would be dredged biannually and the oute. harbor reaches are expected to require some annual dredging.

The benefit-to-cost ratio for the REC plan is 1.7 to 1.0.

(2) Environmental Features. Dredging equipment, timing of dredging, and disposal sites have been carefully chosen to minimize potential environmental impacts of dredging and disposal in Grays Harbor as much as possible without jeopardizing the project. Clamshell dredging will be used for the reaches from Moon Island upstream and hopper dredge will be used for other reaches. However, hopper dredging may be used for the western one third of Moon Island should it prove to be more economical. Refer to table EIS 2-4 for dredging schedule. The use of clamshell dredging will minimize the entrainment and mortality rates of crabs and fish in those reaches since the entrainment rate for clamshell is 95 percent less than the hopper dredge rates (Armstrong et al., 1981). Clamshell dredging also reduces the potential for resuspension of contaminants (more so than hopper dredging) and other water quality problems associated with the silty material in the inner harbor. Hopper dredges have been selected for Outer Bar-Crossover reaches work due to cost efficiency and logistics. The hopper dredge is the most effective method of dredging for Outer Bar, Entrance, and South reaches due to the combination of greater depths at these locations and sea conditions across the bar to the ocean. Although hopper dredging is the most cost efficient dredge to use at South reach and Crossover reach, dredging activities have been scheduled during winter months to avoid dense populations of adult crabs. Inner harbor dredging is scheduled to avoid large concentrations of juvenile salmonids migrating out of the harbor. In addition to minimizing the impacts to the estuary, the vast majority of the silty inner harbor sediments will be discharged in the ocean.

Two in-harbor disposal areas have been proposed for combined disposal of 9.9 million c.y. of dredged material during initial construction. One site is located at the end of the South Jetty which would be used as the in-harbor disposal site for silty material; in addition, the new Point Chehalis site would be used primarily for disposal of sands (see plate 3 for location of disposal site). Gravels from Cow Point will be discharged at Point Chehalis. Reevaluation of the disposal of gravels will be necessary should an upland disposal site become available.

Model studies, current measurements, analysis of historical bathymetry changes, and recent drifter studies conducted by the Corps of Engineers indicate that material discharged at South Jetty and new Point Chehalis will be effectively flushed out to the ocean, thus reducing the potential for recirculation of silts into the estuary. Table EIS 2-3 summarizes the quantities and percent composition of material to be discharged at each disposal site. During the proposed O&M, impacts to important resources in most of Grays Harbor may not be substantially greater than those of the existing O&M, except for increased impacts to Dungeness crabs due to the need for maintenance dredging the Outer Bar each year.

(3) Mitigation and Monitoring. Impacts associated with the construction of this project under the REC plan have been reduced substantially through planning and coordination with various state and Federal resource agencies. Upland areas will only be used for dredged material disposal if any of the harbor sediments are determined to be unacceptable for open-water disposal or if acceptable upland sites become available. Channel widening will occur to the deeper side of the channel to the maximum extent possible to avoid impact to shallow water fish rearing and feeding areas and to reduce the total amount of dredging required. Dredging in the outer harbor has been scheduled to avoid periods of maximum Dungeness crab abundance. No eelgrass beds or salt marshes will be destroyed through dredging operations. The project has been reduced in size from previously planned dimensions to the minimum channel dimensions allowable for safe navigation. Finally, the inner and outer harbor dredging schedules, equipment to be used, and disposal sites for each channel reach under the REC plan were chosen after considering the environmental impacts and economic costs of various options.

Adverse environmental impacts associated with the REC plan include the loss of 4 acres of shallow subtidal inner-harbor habitat. Loss of the important juvenile salmonid feeding and rearing area will be mitigated by purchasing approximately 4 acres of diked marsh in the inner harbor and transforming this area into shallow subtidal and intertidal habitat.

Impacts to Dungeness crabs will be avoided by physically modifying dredges operating in Grays Harbor to entrain fewer crabs. This modification would take the form of lighting, plow-type structures, electricity or other modifications on the hopper dredge drag arms to scare or push crabs away as the dredge passes. These approaches to reduce crab entrainment will be evaluated during CP&E phase studies for this project.

If dredge modification does not appear to be a viable way to substantially reduce the number of crabs entrained, the following measures would be considered for mitigation: (1) increasing survival of crabs (especially juveniles) already present in the harbor through altering and improving presently available habitat and/or (2) developing means to increase the natural survival of crabs in Grays Harbor through selective relocation. The actual amount of mitigation for crab losses depends upon the significance of the loss to the Grays Harbor population and the success of the dredge modification program. Mitigation efforts will be refined through CP&E phase studies. Reference paragraph 4.33 of the Feasibility Report for a list of special CP&E studies. The present apportioned mitigation costs total approximately $550,000

While the dredging equipment and schedules have generally been selected to reduce environmental impacts, water quality in the inner harbor may be degraded during project construction. A water quality monitoring program will be required to insure that adequate water quality for fish survival is maintained during construction in accordance with the Washington State Water Quality Guidelines for Dredging in Inner Grays Harbor and Lower Chehalis River.

Two other monitoring programs will be required in conjunction with project construction and maintenance. Monitoring will occur at the ocean disposal sites during both construction and project maintenance disposal activities. This monitoring is described in appendix A, paragraph 4.5b of this EIS along with the ocean disposal site studies which are proposed for the CP&E phase of this project. Monitoring will also be required to insure that the level of contaminant concentrations in the sediments to be dredged over the 50-year life of the project do not change substantially. This sediment chemical analysis should occur periodically (every 5 years) or whenever there is reason to believe new contaminants may be present in significant concentrations.

2.03 Evaluation of Alternative Disposal Sites. Six disposal sites have been investigated by the Corps of Engineers. Each site has been evaluated for its value as habitat for fish and wildlife resources as well as for the cost of utilizing it for dredged material disposal. See table EIS 2-5 for a summary of the evaluation. The cost by reach for using recommended sites is detailed in plate 10.

a. Potential Upland Sites. Approximately 536 acres of land near Junction City (see plate 7) were investigated as potential disposal areas. This area was found to be a tidally influenced wetland habitat which would be seriously impacted if used as a disposal area for dredged

material. Due not only to the serious impacts but also to the substantially high mitigation costs that would result with use, this area is not considered as a disposal area in the Recommended Plan.

The other upland site investigated was a 51-acre, 1 million c.y. capacity, log storage site located in South Aberdeen, northwest of Cosmopolis (see plate 7). This upland log storage site is proposed as an alternative site for disposal of up to 1 million c.y. of sediments if some material is determined unacceptable for open-water disposal. Bioassay tests are currently being conducted and a determination of the suitability of the harbor sediments for open-water disposal will be made upon completion of these tests (reference Exhibit 2 of Appendix A). Due to the presently disturbed nature of the site, impacts are expected to be minimal. No threatened or endangered species are present at this site.

In addition, approval of Grays Harbor Estuary Management Plan (GHEMP) could result in a predesignation of certain areas as dredged material disposal site, e.g., Bowerman Basin. Should upland disposal sites become available an evaluation will be made during CP&E.

b. Estuarine Open-Water Sites. The South Jetty site and a new Point Chehalis site consist of subtidal estuarine habitats below -50 feet MLLW. These areas support benthos already adapted to a disturbed environment (due to dredged material disposal, wave action, currents, and ship traffic). The loss at these areas would be a burial and destruction of fauna and habitat in the immediate 120-acre Point Chehalis disposal site area and approximately 60 acres at the South Jetty site. These areas will be disturbed annually by disposal of maintenance dredged material. Recreational and commercial fishing for rockfish does occur at the South Jetty which is a good rockfish and crab habitat composed of a cobble and shell substrate. Annual disposal of fine material at the South Jetty site may change the substrate to a habitat unsuitable for rockfish and crabs. Point Chehalis and South Jetty sites have been chosen as disposal sites because current measurements indicate that material will be effectively carried out of the estuary, thus reducing concern that some material may be recirculated onto harbor mudflats, eelgrass beds, and oyster beds. Also, disposal of material is desirable at these sites to stem the undercutting of the South Jetty as a result of tidal scouring action.

c. Ocean Sites. Potential ocean disposal areas for the Grays Harbor project include sites in the near shore sands (which occur between 0-130 feet water depth, sites 2.5 A and B and 3.5 A and B, plate 7), the midshelf silt deposit (130 feet water depth, sites 5A and 5B), and the relict gravels (deep water west by northwest of the estuary mouth, site 8A) and one beach site, 1A. All sites are approximately located in the navigation lanes in order to avoid direct impacts to crab fisheries, except for site 1A which is located south of South Jetty to prevent additional scouring of the beach. Site 8A is reported by state resource agencies as an area of low fishery activity (too shallow for shrimpers

and draggers, too far out for sports fisheries, and of inappropriate substrate (gravel) for crab fisheries). Detailed studies to be performed during the Continuation of Planning & Engineering (CP&E) phase of the project will allow a more complete evaluation of these sites and will permit selection and formal designation of an ocean disposal site(s) for the Grays Harbor project.

2.04 Comparative Impacts of Alternatives. Comparative engineering features and environmental impacts are shown in table EIS 2-2 and table EIS 2-6, respectively.

TABLE EIS 2-5

DESCRIPTION OF THE ALTERNATIVE DISPOSAL SITES

Site Location	Type	Size (Ac)	Volume Capacity	Transport Method	Depth	Habitat	Relative Cost for Use
Point Chehalis	open water	120	2 million c.y./year	barge or hopper	50-80 feet below MLLW	subtidal, sandy	low
South Jetty	open water	60	2 million c.y./year	barge or hopper	50-80 feet below MLLW	subtidal, cobble sand, sandy silt	low
Upland in South Aberdeen	confined	51	1 million c.y.	pipeline	upland	upland, log storage	low
Junction City (several sites)	confined	208	3.5 million c.y.	pipeline	upland	wetlands (marsh)	Very high due to high mitigation cost of filling wetlands.
Ocean	open water	160 (ea)	N.A.	barge or hopper		Deepwater sand, silt, or gravel depending on site selected.	Medium to high depending on distance.
Sites 2.5A (2-1/2 miles)					-60 feet below MLLW		
3.5A (3-1/2 miles)					-100 feet MLLW		
3.5B (3-1/2 miles)					-100 feet MLLW		
8A (8 miles)					-150 feet MLLW		

TABLE EIS 2-6

COMPARATIVE IMPACTS OF PROJECT ALTERNATIVES WITHOUT MITIGATON

Resource	Alternative 1 (No Action)	Alternative 2c (REC Plan)	Alternative 2a (NED Plan)	Alternative 2b (LED Plan)
Water Quality	Continued temporary decrease during O&M disposal of dredged material.	Short term temporary decrease during construction and at disposal site.	Greater increases in turbidity/suspended solids at Point Chehalis.	Same as REC Plan
Air Quality	Possible decrease in quality due to continued development.	Same as No Action	Same as No Action	Same as No Action
Sediment Quality	None	None	None	None
Wetlands	None	None	Possible recirculation of [illegible] and siltation of eelgrass beds.	None
Intertidal and Shallow Subtidal	None	Loss of 2 acres at south Aberdeen (-10 to -5 MLLW) and 2 acres at Cow Point (-5 to MLLW).	Same as REC Plan	Same as REC Plan
Aquatic Invertebrates	Continued temporary decrease at Point Chehalis and in channel during O&M.	Removal of in channel and disposal site benthos, permanent change in community structure at dredged areas and disposal sites. Convert 600 acres of undisturbed habitat to disturbed habitat.	Same as REC Plan	Same as REC Plan
Crab Fishery	None	Substantial impacts to crab population.	Severe impacts on crab population.	Least impact on crab population.
Anadromous Fish	None	Minimal impact.	Probable impact during salmon out migration.	Minimal impact.
Unavoidable Adverse Impacts	Continued yearly disturbance of channel benthos due to O&M.	Removal and destruction of channel and disposal site benthos.	Smother benthos at disposal sites. Removal and destruction of channel benthos. Potential for recirculation and subsequent siltation on eelgrass beds, oyster beds, and mudflats, and no recirculation of silts in estuary.	

SECTION 3. AFFECTED ENVIRONMENT

3.01 Project Area. Grays Harbor estuary is located at the mouth of the Chehalis River on the southwestern Pacific Ocean coastline of Washington, approximately 110 miles south of the entrance to the Strait of Juan de Fuca and 45 miles north of the Columbia River. The estuary lies wholly within Grays Harbor County (figure EIS 3-1). Moving landward, the estuary can be divided into two major areas: the outer harbor extending from the Pacific Ocean east to Point New and the inner harbor extending east from Point New to Cosmopolis. The navigation channel is divided into eight reaches (figure EIS 3-1).

Grays Harbor is characterized by expansive mudflats, which are bare during low tides, and intervening channels that have been formed by the ebbtide discharge and the many rivers and creeks entering into the estuary. The most important of these channels is the North Channel, used for shipping, extending from the deep water near the estuary mouth to Cow Point. The principal rivers entering Grays Harbor are the Chehalis, Humptulips, Hoquiam, Wishkah, Johns, and Elk. Except for the Chehalis and the lower reaches of the Hoquiam, the tributary rivers are not important for navigation.

The land surrounding Grays Harbor is covered by heavy forests which provide for the bulk of the region's economic subsistence through timber harvest and export. Pacific County and the western portions of Lewis, Jefferson, Mason, and Clallam Counties are considered tributary to Grays Harbor in socioeconomic and environmental characteristics due, in part, to the region's heavy dependence on forest resources that historically have been shipped out of the Port of Grays Harbor. Grays Harbor County maintains a population of approximately 66,300 (1980 census); the entire area totals 5,000 square miles. Commercial and recreational fishing, fish processing, tourism, and boating are other important contributors to the region's economy.

The city-ports of Aberdeen, Hoquiam, and Cosmopolis, all located at the head of the estuary, are the major urban centers for the region. Dredged channels provide deep-draft access to port and industrial facilities. Public and private marinas exist throughout the harbor; Westport Marina at Westport serves as the base for one of the Pacific Northwest's largest commercial and recreational fishing fleets.

The economy of Grays Harbor and its tributary area has been historically dependent on the forest products industries and related waterborne commerce with most vessel traffic engaged in transportation of wood products (logs, lumber, wood chips, and pulp). Over the past 10 years, waterborne commerce in the estuary has shown a steady increase in both number and size of vessels with allowable drafts exceeding 30 feet trading at the port. Tourism and recreational activities are also becoming increasingly important, albeit seasonal, aspects of the county's economy.

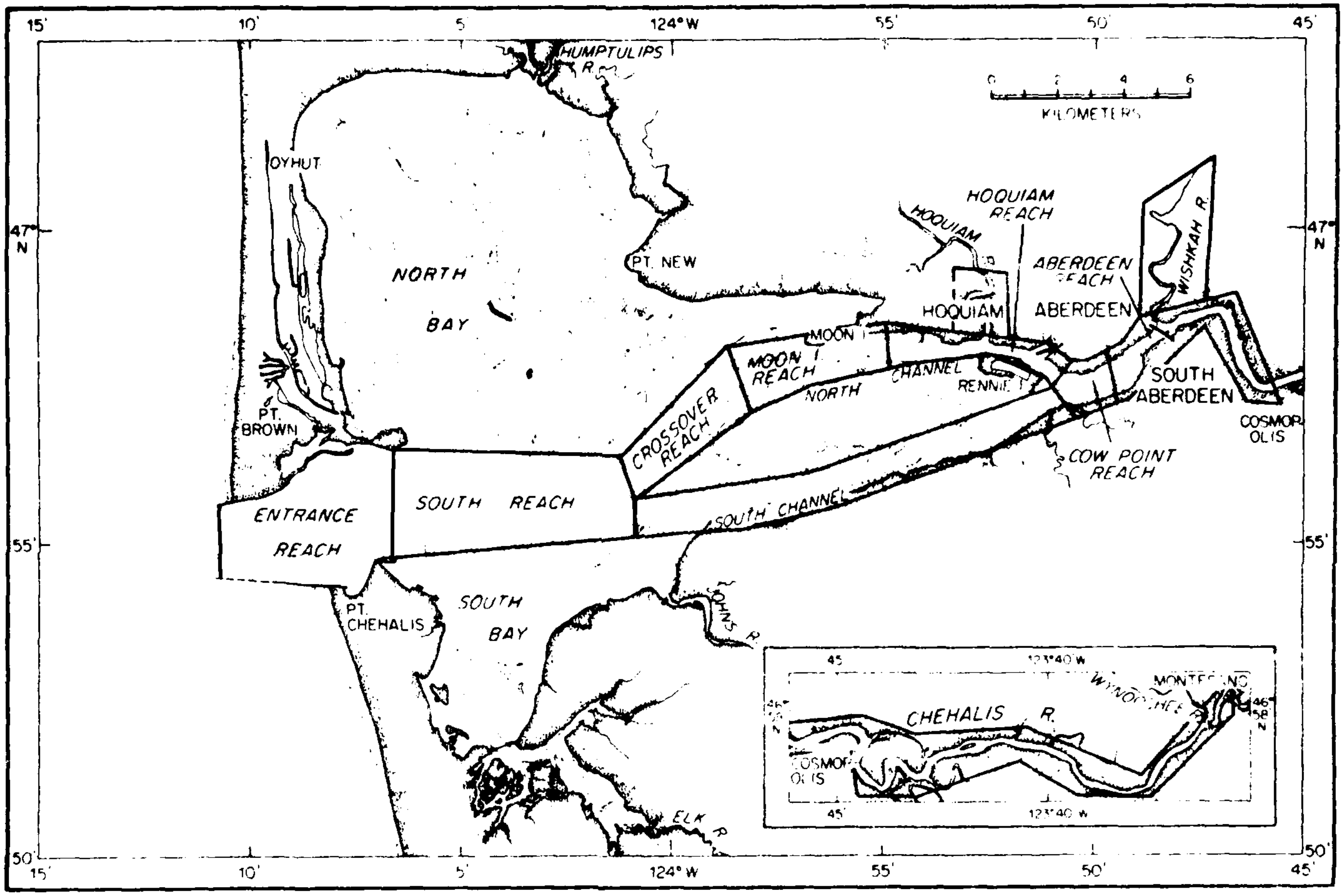


Figure EIS 3-1. Subdivisions of Grays Harbor

3.02 Environmental Conditions. This section describes, in general, the major characteristics of the study area environment. Aspects of the environment that are of special issue to, and significantly affected by, the project are discussed in detail in the Significant Resources, section 3.03.

a. Physical Features and Conditions.

(1) Climate and Weather. At approximately 47 degrees north and 124 degrees west, Grays Harbor lies in a temperate coastal zone influenced by a maritime climate. Summers are cool and dry, and winters are cool and rainy. Rainfall is a major feature of the climate with annual rainfall of approximately 70 to 90 inches a year. Temperatures are mild, rarely freezing, and not often above 75° F.

(2) Air Quality. Grays Harbor County meets Primary Ambient Air Quality Standards. The National Ambient Air Quality Standard (40 CFR 50) and Washington State Ambient Air Quality Standard for high volume suspended particulates are 75 micrograms per cubic meter (ug/m^3) and 60 ug/m^3 (annual geometric mean), respectively. Typical values for suspended particulates in the outer Grays Harbor average 35 ug/m^3, well below the national and state standard. Pollutants are largely from vehicular and marine traffic: mainly carbon monoxide, oxides of nitrogen. and unburned hydrocarbons. There is measurable, although low-level, air pollution from industrial sources on the inner part of the Grays Harbor estuary. Localized air pollution problems occur as a result of high winds that hold emission plumes close to the ground near the source. The major air pollution source within the Aberdeen-Cosmpolis area is sulfur dioxide emission from sulfite pulpmills. Suspended particulate concentrations in the city of Aberdeen show an annual geometric mean of 40 ug/m^3, also below the National Ambient Air Quality Standard, 1981 (Department of Ecology, 1981).

(3) Noise. Ambient noise levels in the harbor vicinity have been measured to be 50 to 60 decibels (db) (A) during the daytime and 4 to 50 db (A) at night which are not considered to be high levels by Environmental Protection Agency (EPA).

(4) Physiography. The Grays Harbor area is a drowned coastal valley sheltered from ocean attack by bay bars and is surrounded on three sides by low hills. Prior to construction of the jetties, the harbor mouth was constricted by two sandspits formed by coastal processes in recent geologic time. Jetty construction has stabilized the entrance to about 6,500 feet wide and caused scour of the bar from about -15 feet MLLW to greater than -35 feet MLLW.

(5) Geology. Reference feasibility report, paragraph 4.08.

(6) Littoral Processes. Reference feasibility report, paragraphs 4.03-4.05.

(7) Estuarine Sedimentation. Grays Harbor acts as a trap for both river and ocean transported sediments. Studies of heavy mineral distribution in Grays Harbor sediments and adjacent beaches and rivers confirm that marine sediments of Columbia River origin are transported to the mouth of the estuary by littoral currents and eventually some are transported into the estuary via tidal currents and wave action along the North Jetty. Fine grained and sandy material is also carried out of the estuary, generally along the toe of the South Jetty during ebb flows. The estuary also receives river transported sediments in its northern, southern, and eastern parts. A general sediment regime of Grays Harbor estuary (Phipps, et al., 1974) is provided in figure EIS 3-2. Phipps grain size analysis indicates that the sediments become finer grained toward the head of the estuary and all the silty sands and muddy silts lie in the mixed or fluvial sediment provinces.

(8) River Sources. Reference feasibility report, paragraph 4.08.

(9) Water Conditions

(a) Hydrology. The Grays Harbor watershed measures about 2,550 square miles and includes the Chehalis, Hoquiam, Wishkah, Humptulips, Johns, and Elk River basins. The Chehalis is the largest river system, contributing 80 percent of the total freshwater flow into the Grays Harbor estuary.

(b) Physical Oceanography. Reference feasibility report, paragraph 4.06.

(c) Water Quality. Dredging and discharge of Grays Harbor sediments has the potential to affect water quality and is discussed in detail in Significant Resources, paragraph 3.03a.

b. Biological Features.

(1) Terrestrial Ecology. The terrestrial ecological resources of the area include numerous plant and animal species in a diverse array of habitats ranging from man-created, rocky shore marine communities near Westport to thick forests surrounding the estuary. Dense conifer forests, classified as coastal Sitka spruce (Picea sitchensis) and western hemlock (Tsuga heterophylla) zones by Franklin and Dyrness (1973), surround the estuary. Logging and natural flood plain conditions along lower river courses have encouraged stands of rapidly growing decidiuous trees such as red alder (Alnus rubra) and willow (Salix spp.) to become established. The canopy of trees and dense underbrush associated with deciduous forests provides habitat for various mammalian and avian species. Terrestrial vegetation in the immediate area of the proposed project falls into four general categories: red alder association, riverside brush and trees, riverside forbs and grasses, and freshwater marshlands (Smith et al., 1976). Over 50 species of mammals, utilizing

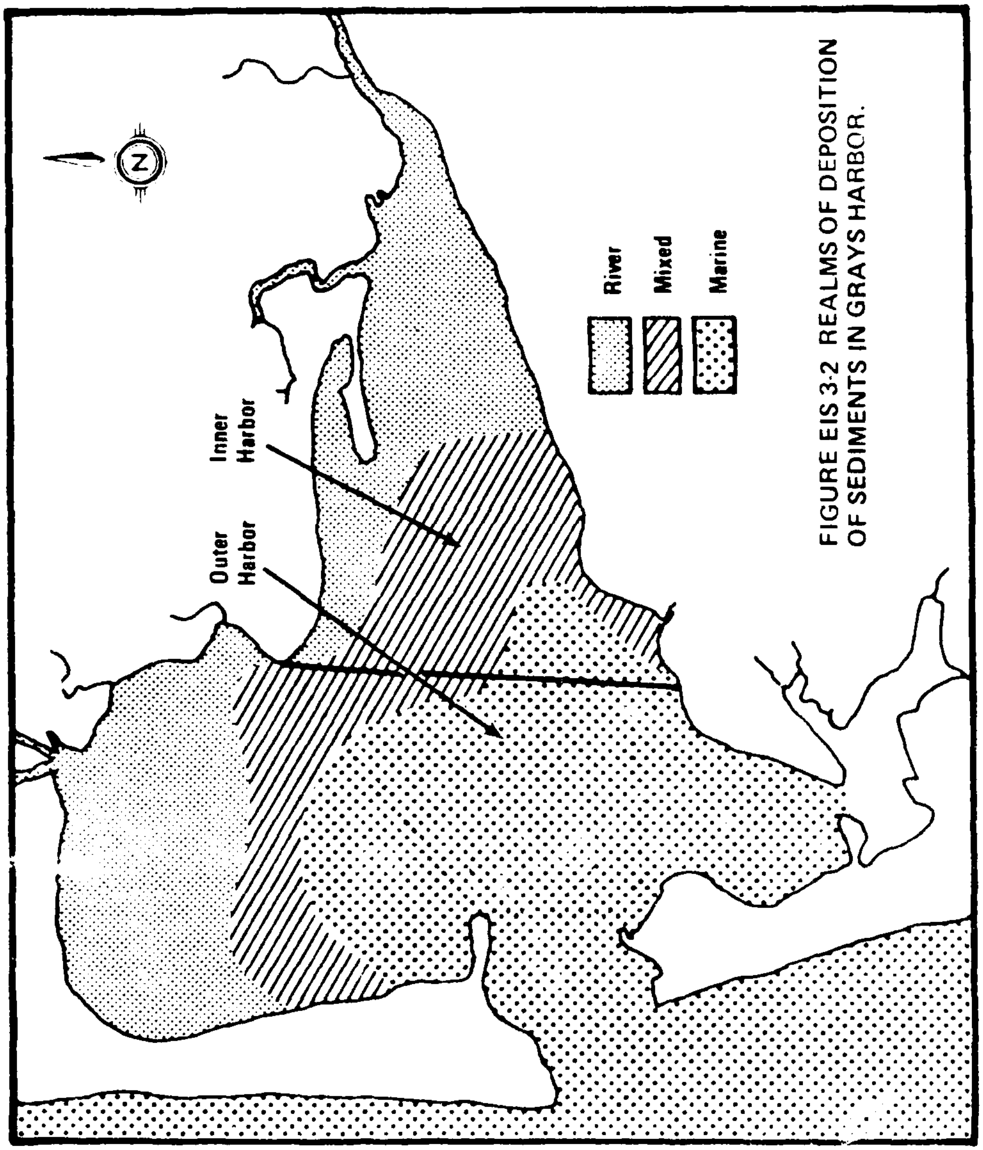


FIGURE EIS 3-2 REALMS OF DEPOSITION OF SEDIMENTS IN GRAYS HARBOR.

six different habitat types, are found in Grays Harbor (Mudd and Smith, 1976, and Kalinowski et al., 1981).

About 15 mammal species are found in the Grays Harbor proximity, including fur bearing mammals such as beaver (Castor Canadensis), the most economically important fur bearer of the region; raccoon (Procyon lotor); muskrat (Ondatra zibethica); mink (Mustela vison); river otter (Lutra canadensis); red fox (Vulpes vulpes); coyote (Canis latrans); and longtail and shorttail weasel (Mustela frenata erminea, respectively). Important game mammals are blacktail deer (Odocoileus hemionus columbianus), black bear (Ursus americanus), and Roosevelt elk. Diked saltmarsh habitats in Grays Harbor are very productive for small mammals. These higher elevations, former salt-marsh areas, are normally located next to riparian wooded swamp habitats. These habitats are the chief furbearer and game habitats, especially the riparian wooded swamp.

(2) Marine Ecology. Marine habitats include open ocean and estuarine environments. Grays Harbor is a typical estuary supporting many important habitats. A detailed discussion on marine ecology is included in Significant Resources, paragraphs 3.03b(1) and (2).

(3) Avian Fauna. Grays Harbor is composed of diverse and productive habitats that support numerous species of birds. Grays Harbor habitat diversity has attracted approximately 325 species of birds, roughly 80 percent of all species found in Washington State, and is a major stopover ground for migrating species (Herman, 1981). Avian fauna are discussed under Significant Resources, paragraph 3.03b(2)(b)4.

(4) Threatened and Endangered Species. There are several birds and marine mammal species found in Grays Harbor that are classified as "threatened or endangered" by the Endangered Species Act of 1973. They are discussed in Significant Resources, paragraph 3.03b(3).

c. Historic and Prehistoric Features. A review of the National Register of Historic Places (Federal Register, 18 March 1980, and monthly supplements through Vol. 47, No. 71, 13 April 1982), the Washington State Register of Historic Places, and archeological records at the University of Washington, Department of Anthropology, indicate that no known historic or archeological sites of cultural significance are located within, or will be impacted by, the proposed dredging or disposal areas. Some aspects of this project have been coordinated previously with State Office of Archaeology and Historic Preservation. Since disposal sites have been changed, further coordination with this office will be required. It is our determination based on an all deepwater disposal project that there will be no effect to cultural resources due to the project. A letter of concurrence will be requested from the State Historic Preservation Officer during public review of this document.

(1) Upland Sites. A cultural resources reconnaissance of several alternative disposal areas (see plate 7 - Junction City sites) was

conducted by Seattle District archeologists in October 1980. The reconnaissance investigation found no indication of prehistoric occupation or historic use. These disposal sites are wetlands and are not part of the recommended plan. If these sites are proposed for use in the future, further investigations of the impact area by a qualified archeologist will take place during construction.

(2) In Harbor Sites. Twenty-four sediment core samples were taken from the navigation channel and examined for the presence of cultural resources by a Seattle District staff archeologist. An additional 25 sediment cores from the inner harbor were carefully examined for cultural resources by AM Test Laboratories in Seattle during the chemical analysis of Grays Harbor sediments (AM Test, 1981). No material of cultural resource significance was found in any of the examined sediment cores.

d. Socioeconomic Features of the Project Area. See paragraph 3.01 of this report.

3.03 Significant Resources. The resources discussed in this section include those aspects of the Grays Harbor environment that are of special importance to the Recommended (REC) Plan. These resources are of public interest and may potentially be impacted but will not necessarily be adversely affected due to the project.

a. Physical Features.

Water Quality. Figure EIS 3-2 shows the dividing line in Grays Harbor between the outer harbor waters classified as "A" (excellent) and the inner harbor classified as "B" (good) by Washington Department of Ecology (WDE) criteria. These WDE water quality criteria include consideration of dissolved oxygen (DO) levels, temperature, pH, and turbidity of the water.

The first comprehensive water quality investigation in Grays Harbor conducted by the predecessor agency to WDE in the late 1930's showed DO concentrations often lower than minimum levels required for fish survival. Ericksen and Townsend (1940) observed large numbers of distressed and dead fish, shrimp, and other aquatic animals in 1937, 1938, and 1939. Past and present industrial discharges have had a major impact on water quality in the inner harbor. Wastes often accumulate as a result of low river inflows and limited flushing which, in concert with heavy sedimentation from the Chehalis River, contribute to low DO levels in the inner harbor. Additional organic waste discharges would likely further reduce water quality. However, there are indications that the historic trend of degrading water has been reversed as water quality in the estuary has improved in the last 10 years due to improved industrial waste treatment in recent years (Loehr and Collias, 1981).

(a) Toxicants. Grays Harbor studies in 1974 and 1975 (Grays Harbor College, 1976) indicated the presence of toxicants and pollutants in the water and harbor sediment. Therefore, further comprehensive sediment sampling and elutriate testing for contaminants in Grays Harbor was performed in 1980 and 1981 by the Seattle District. The results of this comprehensive testing program indicated that contaminant concentrations in the sediments increase toward the inner harbor as the sediments become finer. Contaminant concentrations were generally found to be higher in the proposed channel areas adjacent to the presently maintained channel (see table A-2a and 2b, appendix A). Of the priority pollutants tested, only nine contaminants were found to be present in water elutriates of Grays Harbor sediment to be dredged and four (copper, zinc, PCB's and BHC) exceeded EPA criteria. The effects of these contaminants are being evaluated during ongoing biological tests (see appendix A, exhibit 2) Details and results of this recent two phase water and sediment sampling program are included in appendix A, paragraphs 3.5b(1) and (2).

(b) Human Health. *Klebsiella*, a bacterium isolated from pulp and papermill wastes in Grays Harbor, is a member of the fecal coliform group of bacteria and is considered to be a low risk pathogen. Existing data suggest that the disturbance of sediment contaminated by *Klebsiella* should not present a serious threat to human health due to several factors. These factors are: (1) the low chance of direct human contact with highly contaminated sediments; (2) the high probability of reduced growth rates and reduced survival of *Klebsiella* in low nutrient, cold, saline water; and (3) low probability of encountering one of the few *Klebsiella* which are pathogenic (Storm, 1981). The presence of fecal coliform bacteria in Grays Harbor sediments has been identified. Recent monitoring efforts during maintenance dredging has shown that the redistribution of these bacteria into sensitive areas (e.g. shellfish harvest areas) is minimal. Coordination of dredging schedules with resource agencies would insure that shellfish harvest areas are protected in the event of a bacterial outbreak.

b. Biological Features.

(1) Open Ocean Features.

(a) Flora. In the study area (defined as within 8 miles of the harbor entrance, see paragraph 2.03c on ocean disposal of dredged material), phytoplankton, mainly diatoms and microflaggelates, constitute the bulk of the flora. Phytoplankton is the foundation of most of the food chains in the study area. In an analysis of stomach contents of 11 species of finfish at the Columbia River ocean disposal site, Durkin and Lipovsky (1977) found that phytoplankton were the primary diet of anchovies and that anchovies were, in turn, eaten by nine of the other fish species. There is a surf zone association of two diatom species that is the main food for large razor clam populations which extend from the Columbia River northward at least 63 miles (Lewin, et al., 1970).

(b) Fauna. The fauna within the study area can be divided into three interacting communities: benthic, demersal, and pelagic.

1. Benthic Community. The benthic community consists of those organisms living in the sediment or near the sediment water interface, i.e., marine worms, crustaceans, and molluscs. This community depends on the continued descent of organic materials from the overlying waters for nourishment. The Dungeness crab (Cancer magister) is an economically important benthic species. Some of the best crabbing grounds are located off the coast of Grays Harbor. The potential impacts to crabs are great and are discussed in section 4, paragraph 4.02b(2)(b).

2. Pelagic Community. The pelagic community consists of those organisms drifting (plankton) or swimming (nekton) in ocean waters. The plantonic fauna consists of zooplankton which feed on phytoplankton.

The primary pelagic commercial fishing in Washington occurs off the coast of Grays Harbor. The main catch consists of coho (Oncorhynchus kisutch) and chinook (O. tshawytshca) salmon. Some important pelagic marine fish inhabiting coastal waters in the proximity of the Grays Harbor entrance include the Pacific herring (Clupea harengus pallasi), northern anchovy (Engraulis mordax), Pacific sardine (Sardinops sauax), surf smelt (Hypomesus pretiosus), shiner perch (Cymatogaster aggregata), striped seaperch (Embiotoca lateralis), pile perch (Rhacochilus vacca), and the redtail surfperch (Amphistichus rhodoterus).

Occasionally the albacore tuna (Thunnus alalunga) and jack mackerel (Trachurus symmetricus) are found when warm, southern currents invade the Pacific Northwest.

The marine mammal fauna reported for the project area is extensive. Table EIS 3-1 lists the marine mammal species, their relative occurrence, and their legal status (if threatened or endangered) as reported in Volume 43, Federal Register No. 238, 11 December 1978. Endangered species are addressed in paragraph 3.03b(2)(b)5. Larrison (1976) considers the harbor porpoise to be the most abundant marine mammal along the Pacific Northwest coast; it is most often found in coastal and estuarine waters (Eaton, 1975; and Isakson and Reichard, 1976). Other common species include the Northern or Steller sea lion, the California sea lion, and the Harbor seal which, according to Isakson and Reichard (1976), has been identified as inhabiting 15 critical resting and breeding sites within Grays Harbor.

(2) Estuarine Features. Wetland habitats play an important role in the estuarine environment. They make a substantial contribution to the food base of the estuary. A second important wetland function is provision of marine habitat. Wetlands provide habitat for Dungeness crabs and juvenile salmonids, functioning as nursery and feeding areas and as a transition zone for salmonids' physiological adaptation from fresh to saltwater. A third important function of wetlands is the prevention or reduction of siltation and erosion.

TABLE EIS 3-1

MARINE MAMMALS THAT OCCUR
WITHIN THE GRAYS HARBOR STUDY AREA
(from Smith et al., 1980)1/

	Endangered Species Status
Order: Cetacea	
Black or Pacific right whale2/	Yes
Minke whale	No
Sei whale	Yes
Finback or Fin whale	Yes
Humpback whale2/	Yes
Gray whale	Yes
Pacific striped or white-sided dolphin	No
False killer whale2/	No
Killer whale	No
Harbor porpoise	No
Sea Otter	No
Northern fur seal	No
California sea lion	No
Northern or Steller sea lion	No
Harbor seal	No
Northern elephant seal	No

1/Compiled from Eaton (1975), Larrison (1976), Pike and MacAskie (1969), and Northwest Fisheries Center, Marine Mammals Division (1975).

2/Uncommon occurrence in this area.

In addition, wetlands facilitate the absorption of organic and mineral nutrients and the assimilation and concentration of toxic substances, including heavy metals and chlorinated hydrocarbons, from surrounding waters.

Shallow intertidal flats and associated eelgrass, algae, and salt-marsh communities exist throughout and along the margins of the Grays Harbor estuary (see Fig. 3-3) and account for most of the estuary's primary productivity (Thom, 1981). Table EIS 3-2 shows the estimated acreage of these intertidal habitats. Food energy is produced by plant photosynthesis which captures, converts, and stores energy from sunlight. Understanding this transfer provides a means of ascertaining the importance of surficially unrelated biologic communities. Primary consumers which feed on plants or organic detritus in turn provide food for higher life forms. Several food chain pathways found in Grays Harbor ecosystems have demonstrated the extent and persistence of interdependent relationships throughout the flora and fauna of this estuary.

TABLE EIS 3-2

ESTIMATED EXTENT OF INTERTIDAL HABITATS IN GRAYS HARBOR
(From Grays Harbor LRMDP EISS)1/

	Hectares	Acres
Entire Harbor to Extreme High Water (EHW)	22,140	54,708
Intertidal from MLLW to EHW	13,600	33,605
Salt Marshes:		
Low Marshes	919	2,271
High Marshes	514	1,270
Sedge Marsh	81	200
Diked Salt Marsh	441	1,090
Total Salt Marsh	1,955	4,831
Eelgrass Beds	4,740	11,712
Tidal Flats not Vegetated with Vascular Plants (includes areas with benthic macroalgae and diatoms)	6,905	17,062

1/Grays Harbor Long-Range Maintenance Dredging Project, Environmental Impact Statement Supplement No. 2.

(a) Estuarine Vegetation. The higher intertidal areas of Grays Harbor support salt-tolerant vegetation. Many plant species are capable of living in this environment and often grow in very dense, productive stands.

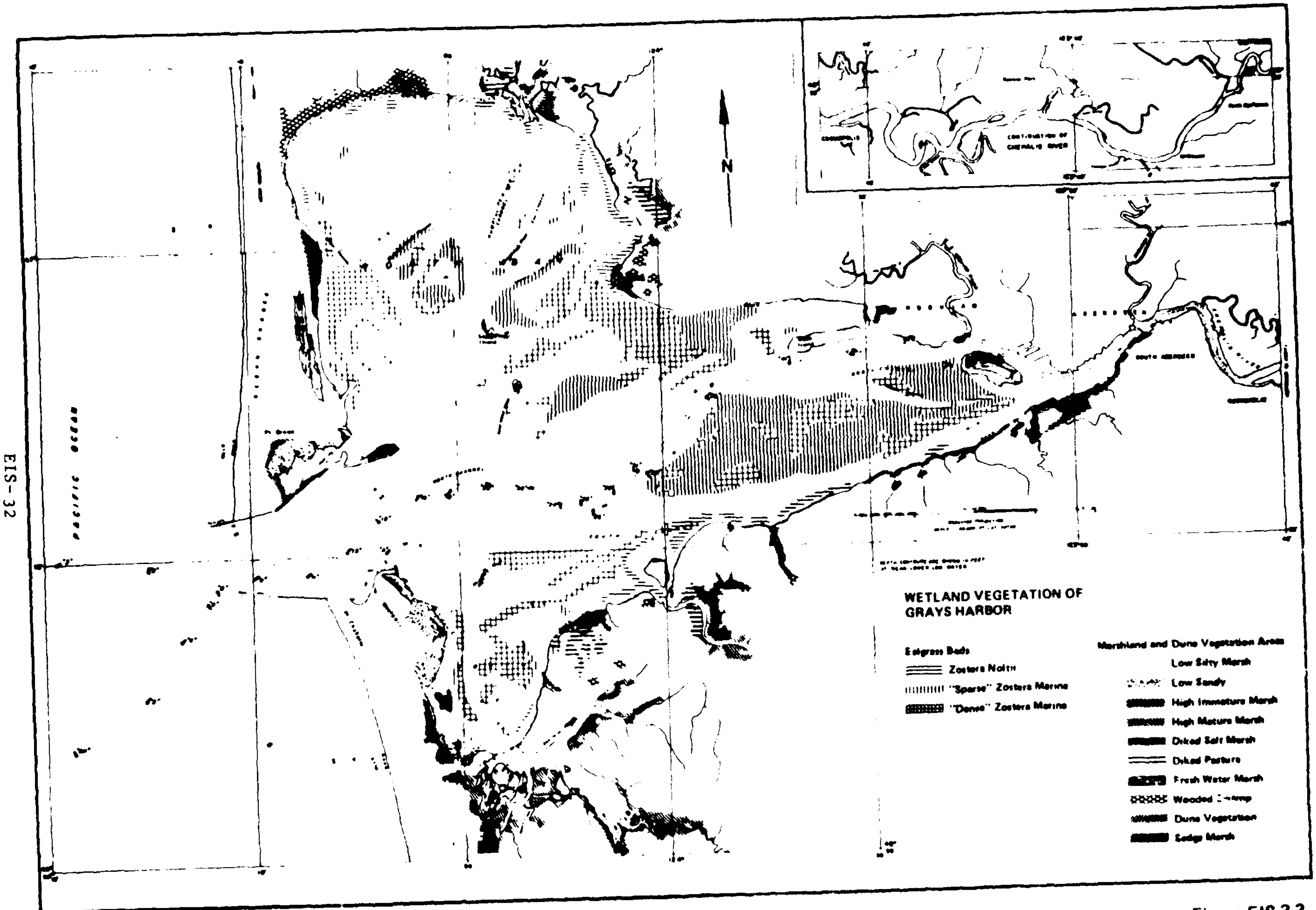


Figure EIS 3-3.

The estuarine vegetation also provides feeding and rearing habitat for fishes, including salmonids, English sole, herring, and smelt, and a nursery habitat for immature Dungeness crab (Simenstad, 1981). In addition, the vegetated areas of the estuary are important habitats for some birds using the Pacific flyway; for resident waterfowl, shore birds, and upland birds; and small mammals.

Two very important plant systems, the eelgrass beds and salt marsh, are extensive in Grays Harbor; phytoplankton and macroalgae are also important, as discussed below.

1. Phytoplankton. Although phytoplankton are the least productive plant group in the estuary, they are considered important primary producers which are the supply of food for zooplankton. Phytoplankton productivity is greater in the outer harbor than in the inner harbor (Thom, 1981). Table EIS 3-3 compares primary production of several types of aquatic flora.

TABLE EIS 3-3

ORGANIC CARBON CONTRIBUTIONS (x 10^6kgC/yr)
OF VARIOUS SOURCES WITHIN THE ESTUARY
(From Thom, 1981)

Source	Inner Harbor 1/	Outer Harbor 2/	Entire Estuary
Marsh Phanerograms	3.36	12.6	16.0
Zostera spp.	49.02	76.78	125.8
Benthic Algae	24.68	46.6	71.3
Phytoplankton	2.34	6.6	8.9
Total for Plant Sources	73.40	142.6	222.0

1/Includes areas Cosmopolis through Bowerman Basin.
2/Includes the area west of Bowerman Basin through harbor entrance.

2. Eelgrass. Two species of eelgrass, *Zostera marina* and *Z. noltii*, cover approximately 11,680 acres of mudflat in Grays Harbor. *Z. marina* occurs from the -3- to the +6-foot MLLW elevations, while *Z. noltii* occurs at higher elevations (+3- to +6-foot tidal levels). The locations (indicated on figure 3-3) and densities of the eelgrass beds in Grays Harbor have been previously described (Smith et al. 1976; Smith et al., 1977; Miller, 1978).

Eelgrass is an important primary producer in the Pacific Northwest (Phillips, 1974), and along with salt-marsh plants, is the base of many food chains in estuaries (e.g., primary food source for black brants). Additionally, eelgrass beds serve as an important habitat for several species of invertebrates and fish.

3. Macroalgae. Twenty-three taxa of macroalgae were identified in Grays Harbor estuary (Thom, 1981), with their distribution limited by availability of hard, stable substrata (e.g., logs, roots, boulders) for attachment. The most widespread species were Enteromorpha intestinalis and Fucus distichus spp. edentatus. Productivity rates varied among the major algal species and are listed in Thom (1981).

4. Salt Marsh. Undiked salt marsh presently covers approximately 3,740 acres of Grays Harbor. Salt marshes are important for their contribution to the food web and for the habitat they provide for many invertebrates and vertebrates. They have been shown to absorb pollutants, stabilize the substrate, and moderate water temperatures (Adkins and Jefferson, 1973). Arrowgrass (Triglochin maritimum) is common in the lowest marshes, while saltgrass (Distichlus spicata) and pickleweed (Salicornia virginica) dominate higher marsh areas. Other important marsh plants are Deschampsia caespitosa, Scirpus americanus, and Carex lingbyei. In the uppermost intertidal areas which are flooded only by extremely high waters, the diversity of plant species increases. Detailed descriptions of the salt marshes of Grays Harbor are provided in Smith et al., 1976 and Armstrong, et al. 1979.

(b) Estuarine Fauna.

1. Benthic Communities. The most comprehensive surveys of invertebrates published to date are the Grays Harbor Dredging Effects Study (GHDES), appendixes E and N (Albright et al., 1976, and Tegelberg et al., 1976, respectively), and Albright and Bouthillette, 1981. The distributions and life histories of the economically important species in Grays Harbor, and species which are found associated with them, are the best known. Additional information can be found in Smith et al. (1980).

o Oysters. Pacific oysters (Crassostrea gigas) are cultivated in outer Grays Harbor, principally near Whitcomb Flats, and in North and South Bays. The inner harbor is closed to oyster harvest and marketing due to high coliform bacteria levels.

o Clams. Nine species of clams, including the native littleneck clam (Protothaca staminea), Washington butter clam (Saxidomus giganteus), and softshell clam (Mya arenaria), are found in Grays Harbor. The razor clam is the most important sport fishery on the ocean beaches immediately north and south of Grays Harbor.

o Crabs. Dungeness crabs (Cancer magister) are abundant in Grays Harbor, though most are smaller than the legal size limit (6 inches carapace width). Grays Harbor appears to function as a nursery area for juvenile crabs. These juveniles eventually migrate to the ocean. The habitat of this commercially important species ranges from Cow Point, even during periods of very low salinity, throughout the harbor to the Pacific Ocean. Smaller crabs appeared more abundant in the eastern half of the estuary, especially around Rennie Island. Utilization of tidal flats at high tide is common, with the heaviest use found in tidal channels and depressions in the flats. The main channels are heavily utilized during low tides (Tegelberg et al., 1976 and Armstrong et al., 1981). Productive crabbing grounds lie off the coast of Washington, with the major commercial crabbing occurring from 1 December through 1 June (Stevens, 1979).

o Other Benthic Invertebrates. The distribution and abundance of the great majority of invertebrates in Grays Harbor is rather poorly known. Most of the species reported as occurring in Grays Harbor are not of direct value to man but are indirectly important in the food chain as food organisms for, or competitors or predators of, the commercially or recreationally important fish and invertebrates in Grays Harbor.

The three most frequently encountered amphipods within Grays Harbor are Corophium salmonis, Anisogammarus confervicolous, and an Eohaustorious species. C. salmonis appears to be the most numerous benthic macroorganism found in the inner harbor and midharbor flats and intertidal areas, with maximum densities of over 6,100 individuals per square foot having been measured (Albright and Bouthillette, 1981). A. confervicolous is important in the high intertidal areas of the inner harbor and Eohaustorious is the most numerous in the outer harbor. A cumacean, Leptochelia savignyei, was the numerically dominant organism in parts of the outer harbor. Another cumacean, a Diastylis species, is found at Whitcomb Flats and is the most numerous organism in both the North and South Channels (Albright and Bouthillette, 1981).

Capitellid polychaete worms were also present throughout the harbor. Heteromastus filiformis was the most numerous of this kind in the inner harbor. Populations of burrowing shrimp, primarily ghost shrimp (Callianassa californiensis) or mud shrimp (Upogebia pugettensis), occur in the bays and flats of the harbor, while free-swimming shrimp (various spp.) inhabit deeper marine waters offshore. A small commercial fishery exists in Grays Harbor that harvests ghost shrimp for use as bait. Gray shrimp (Crangon sp.) are also abundant within the estuary. See Albright and Bouthillette, 1981, for greater detail.

2. Fish. Grays Harbor is utilized by at least 54 species of fishes both resident and anadromous during various stages of their life histories (Bengston et al., 1976).

o Resident Fish. Large and diverse populations of resident fishes inhabit the estuary, many of which are economically important. The English sole (Parophrys vetulus) and starry flounder (Platichthys stellatus), commerically important species, use the estuary as a nursery for their first year of life. English sole and starry flounder are present in all areas of the estuary (Bengston et al., 1976 and Simenstad and Eggers, 1981).

Table EIS 3-4 summarizes the residence times and life history stages of numerically abundant baitfish in Grays Harbor. Table EIS 3-5 indicates occurrence and relative abundance of baitfish at five sampling sites in Grays Harbor.

Several species of resident fish that are not commercially important are found in great numbers in Grays Harbor. Sculpin, perch, prickleback, and stickleback species are quite abundant. These species provide forage for birds, mammals, and larger fish.

TABLE EIS 3-4

SUMMARY OF RESIDENCE TIMES OF PROMINENT TAXA AND LIFE HISTORY STAGES OF BAITFISH IN GRAYS HARBOR, WASHINGTON, MARCH-OCTOBER 1980 (From Simenstad, 1981)

Species	Life History Stage	Maximum Residence Times (weeks)	Remarks
Northern anchovy, Engraulis mordax	adult	6	Maximum residence during two periods (mid-June to early August, late August to early October); longest residence at Westport.
	juvenile	11	Maximum sustained residence from mid-July to early October; longest residence at Cow Point and Moon Island.
Pacific herring, Clupea harengus pallasi	juvenile	15	Maximum sustained residence from early July to early October; longest residence at Cow Point and Moon Island.
Longfin smelt, Spirinchus thaleichtys	juvenile	9	Maximum residence during two periods (early May to mid-July, early August to early October); longest residence at Moon Island.

Table EIS 3-5. Occurrence and relative abundance of baitfish species at five purse seine sampling sites in Grays Harbor, Washington, March-October 1980. Circles represent rare occurrences; +'s, common occurrences; and X's, commonly occurring in high abundances; see text for definition of these terms. (From Simenstad, 1981).

Species/Life History Stage	Sampling Site				
	Cosmopolis	Cow Point	Moon Island	Stearn's Bluff	Westport
Alosa sapidissima, American shad					
juvenile		o	o	o	
adult	+	+	o		
Clupea harengus pallasi, Pacific herring					
juvenile	+	X	X	X	X
larvae	o	o	o		
Engraulis mordax, northern anchovy					
adult		+	X		X
juvenile	o	+	X	X	
larvae	o	+	X	o	
Osmeridae, smelts					
larvae	o	o	o		
Hypomesus pretiosus, surf smelt					
adult/juvenile	o	o	+	X	X
larvae	o	o	o		
Spirinchus thaleichthys, longfin smelt					
adult	o	+	+	o	
juvenile, larvae	+	+	+		
Allosmerus elongatus, whitebait smelt					
adult			o		
juvenile			o		
Ammodytes hexapterus, Pacific sand lance					
juvenile			o	X	o
larvae			o		

o Anadromous Fish. There are six species of salmonids in the estuary that use various habitats in Grays Harbor for feeding before emigrating to the ocean. The species are chum (Onchorhyncus keta), coho (O. kisutch), and chinook (O. tshawytscha) salmon, and Dolly Varden (Salvelinus malma); steelhead (Salmo gairdneri); and cutthroat (S. clarkii) trout. Other anadromous fish include smelt (Spirinchus thaleichthys), American shad (Alosa sapidissima), and sturgeon (Acipenser transmontanus). Distribution, abundance, and feeding behavior will be discussed below. Distribution of the species is strongly influenced by bottom type, estuary depth, salinity, season, and food organism availability.

Figure EIS 3-4 summarizes the residence periods of salmonids in Grays Harbor. Chum and coho salmon have been reported to migrate through the estuary as rapidly as 2-4 weeks. Generally juvenile chum salmonids migrated through the estuary between March and mid-May, coho between mid-April and late June, chinook between early April and the end of October, and steelhead between mid-May and late July (Simenstad, 1981). Simenstad and Eggers (1981) indicate that the chinook maintained a residual population that continued to grow and reside in the estuary through late summer and early fall.

Fish utilize distinctly divergent prey spectra in Grays Harbor and their diets are typically associated with the predominant epibenthic or neritic habitats in which they are found. Fishes occupying near shore habitats feed predominantly upon epibenthic crustaceans, primarily harpacticoid copepods, cumaceans, and various species of gammarid amphipods. Salmonids in neritic habitats tend to be somewhat larger and feed upon more pelagic prey such as larval fish (particularly the larvae of northern anchovy) and adult (drift) insects. As a general rule, juvenile salmonids feed upon epibenthic crustaceans upon their initial entry into estuaries and, when larger or after some growth, convert to neritic zooplankton during their residency in the estuary (Simenstad, 1981).

3. Marine Mammals. Intertidal flats are used by the harbor seals as haulout areas and pupping grounds. During the summer months, as many as 1,400 harbor seals have been observed in the harbor (Mudd and Smith, 1976). See table EIS 3-1 for a list of other occasional cetaceans in Grays Harbor.

4. Avian Fauna.

o Shorebirds. The Grays Harbor area is an important migratory stopover for approximately 24 species of shorebirds. The western sandpiper is by far the most abundant species (Herman, 1981). During the winter months in Grays Harbor, the dunlin is the most abundant shorebird, with a population of as many as 100,000 birds. Other common shore birds, primarily during migration periods, include least sandpiper, red knot, short-billed dowitcher, and great blue heron. During mid-April of 1981, a peak number of shorebirds in Grays Harbor was estimated at approximately 1,000,000 birds (Herman, 1981), with as many as 50 percent of the shorebirds utilizing the Bowerman basin area (see Figure EIS 3-5). The number of birds in Grays Harbor shorebird population decreased rapidly in late April to approximately 75,000 birds.

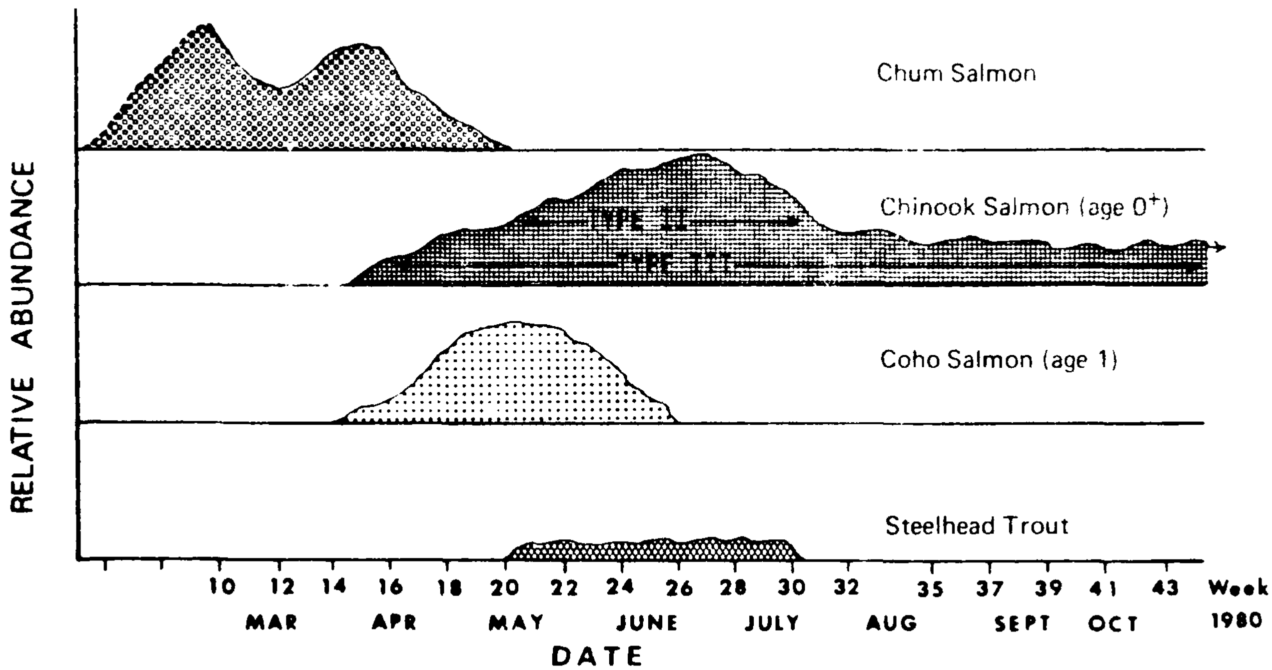


Figure EIS 3-4 Outmigration periods of chum, chinook and coho salmon, and steelhead trout in Grays Harbor, Washington, March - October 1980((from Siminstad 1981).

1/Type II - migrates out of Grays Harbor

2/Type III - portion of the population that remains within the estuary through October

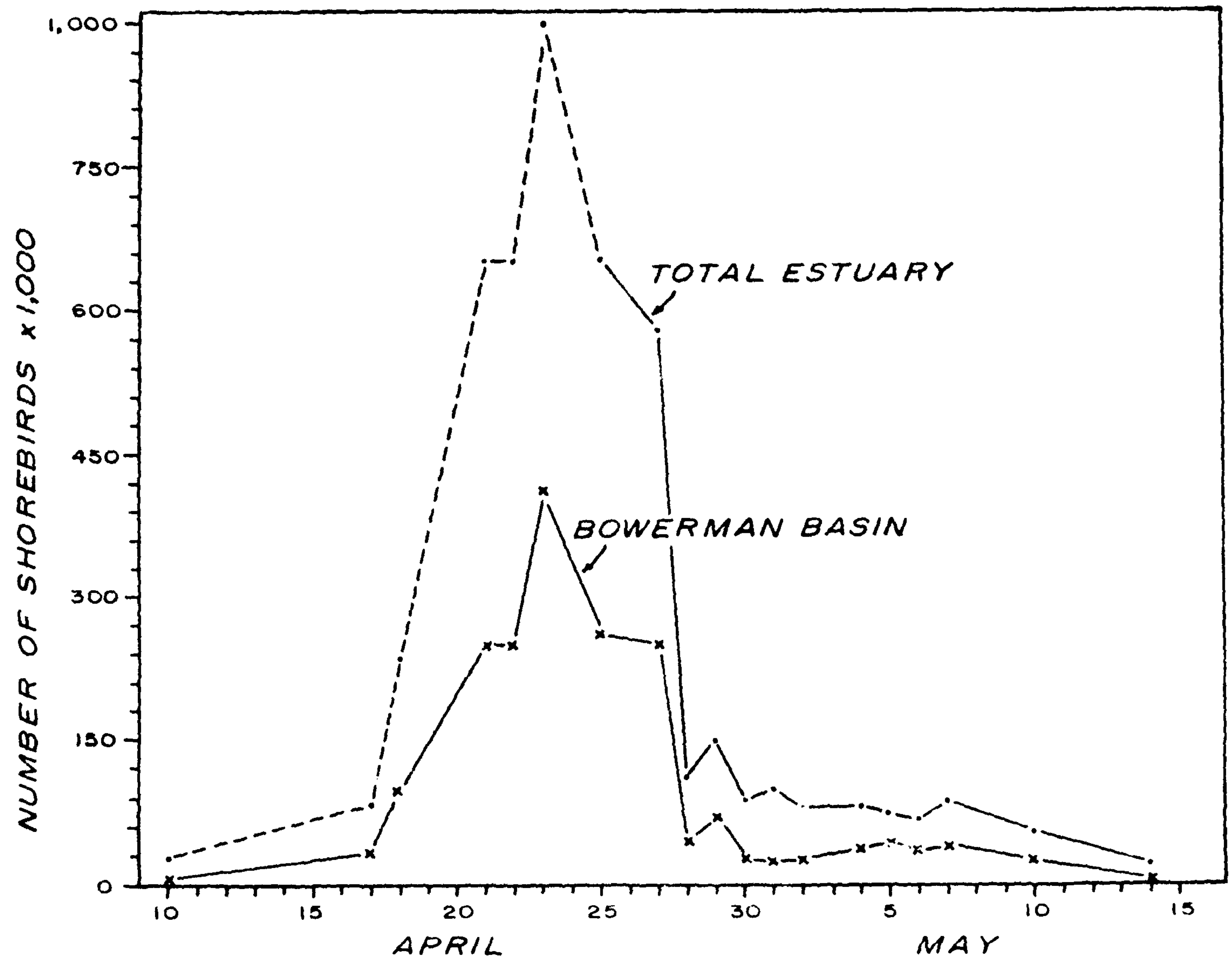


Figure EIS 3-5. *Timing and magnitude of the shorebird migration at Grays Harbor, Washington, spring 1981.* Dashed line represents extrapolation. (Trom Herman & Bulger, 1981)

The Caspian tern deserves special mention as a nesting species in Grays Harbor. Breeding colonies of these terns east of the Cascade Mountains have been nearly eliminated. The only Caspian viable tern colonies in Washington are in Grays Harbor. Nearly 5,000 Caspian terns nest on Whitcomb and Sand Islands.

o Waterfowl. Grays Harbor is also important for other aquatic birds, including western grebes, pelagic and double-crested cormorants, rhinocerous auklets, common murres, several species of gulls and terns, and many species of waterfowl. Populations of waterfowl, dependent upon Grays Harbor during migration, reach a peak in the fall of about 45,000 birds (Smith & Mudd, 1976). The most abundant duck utilizing Grays Harbor is the American wigeon, although pintail, mallard, bufflehead, greater and lesser scaups, canvasback, green-winged teal, white-winged and surf scoters, and ruddy duck are also quite numerous in the harbor. Black brant is the most abundant goose, reaching peak numbers of about 2,000 in April (Smith & Mudd, 1976). Brant feed on the extensive eelgrass beds of Grays Harbor, which are also important fo. scaups and goldeneyes. Grays Harbor is second in importance to Padilla Bay as a wintering area for black brant in Washington.

o Terrestrial Species. The Grays Harbor area supports typical western Washington terrestrial avian fauna. Of special interest are the birds of prey which make use of the wetland habitats, primarily salt marshes and exposed mudflats. The rarest of terrestrial species are the peregrine falcon which prey upon the abundant shorebirds, primarily dunlin during the winter. Bald eagles, rough-legged hawks, marsh hawks, short-eared owls, and snowy owls also utilize the harbor's resources in the winter.

(3) Threatened and Endangered Species. Four species classified as "endangered" by the Endangered Species Act of 1973 are known to occur at Grays Harbor: the brown pelican (*Pelecanus occidentalis californianus*), the Aleutian Canada goose (*Branta canadensis leucopareia*), the gray whale (*Eschrichtius robustus*), and the American subspecies of the peregrine falcon (*Falco peregrinus anatum*). Until recently, most peregrine sightings in Grays Harbor region had been confirmed as the Peale's subspecies (*F. p. pealei*), which is not considered "endangered." Recent sightings in Grays Harbor (19 October 1979 and 27 September 1980) confirm the presence of the endangered American subspecies (Dr. Steven G. Herman, Evergreen State College, personal communication with Ken Brunner, Seattle District, on 6 October 1980).

The northern race of the bald eagle (*Haliaeetus leucocephalus alascanus*) has been included as a threatened species on the list of endangered and threatened species of wildlife and plants of the State of Washington since March 1978 (Federal Register, February 1978) and is regularly sighted in Grays Harbor.

In addition to the species already mentioned, there are six species of whales and one species of turtle that are on the endangered species list and also have been known to occasionally inhabit offshore coastal waters of Washington (Brunner, 1981). Near shore sightings of these animals are very rare in the Grays Harbor area.

One common marine mammal off the pacific coast, the conspicuous gray whale which most frequently migrates within a few kilometers of shore, occasionally strays into the inner areas of Grays Harbor (Eaton, 1975; Rice and Wolman, 1971). The peak of the northward migration here is between early March and early May. The southward migration peaks in late December but may last until early February (Pike and MacAskie, 1969 and Mate, 1979). The humpback whale, although uncommon in occurrence and pelagic in nature, is seen occasionally in the study area in fall and spring while migrating between winter and summer grounds. Humpbacks have been observed entering estuarine waters (Eaton, 1975) while feeding on herring and anchovies, but they mainly feed offshore on euphausids (crustaceans).

SECTION 4. ENVIRONMENTAL EFFECTS OF FINAL ALTERNATIVES

4.01. Introduction. This section discusses and analyzes existing conditions and impacts expected to occur to the Grays Harbor environment due to the widening and deepening of the present navigation channel.

An environmental task force (described in section 5) defined specific studies required for an analysis of the environmental impacts of navigation channel modifications. Twenty reports were written, most of which were contracted by the Seattle District, Corps of Engineers, and were used in the evaluation of impacts provided in this EIS. Final reports from these environmental studies are available from the Seattle District. The studies are listed in table EIS-4-1.

4.02 Continue Existing Conditions (No Action). Should the no-action plan be implemented, the existing Seattle District operation and maintenance (O&M) dredging program would continue to maintain the present federally authorized -30-foot mean lower low water (MLLW) navigation channel. Maintenance dredging and disposal would continue to disturb, remove, and partially destroy resident benthic communities in the channel. Dungeness crab mortality associated with the present maintenance dredging program would continue to reduce the Westport crab harvest (4,200-10,000 fewer crabs harvested per year) by an estimated .84 percent per year. Opportunistic invertebrate species (organisms with high reproduction rates, short generation times, and great dispersal ability) reside in frequently disturbed areas and would continue to recolonize disturbed areas (McCauley et al., 1977) in Grays Harbor after the annual dredging.

Juvenile salmonids are presently protected in the inner harbor by restricting maintenance dredging in the shallows above -15 feet MLLW during spring migration. Some fish may be entrained by the dredge although salmonid entrainment is very low or nonexistent (Armstrong, 1981) with hopper and clamshell dredges. Therefore, minimal impacts to juvenile salmon would continue.

Water quality in Grays Harbor has been improving in recent years (Loehr and Collias, 1981) but is impacted annually by maintenance dredging. Short-term, nonlethal changes in turbidity and dissolved oxygen have been documented near operating dredges in the inner harbor. Water quality is presently monitored when dredging in the inner harbor if the Chehalis River flow falls below 2,500 cubic feet per second (c.f.s.) This monitoring insures that fish and invertebrates in Grays Harbor are protected from depletion of dissolved oxygen in the water.

Water quality and biological impacts to the ocean from the no-action plan would be negligible.

TABLE EIS 4-1

GRAYS HARBOR AND CHEHALIS RIVER IMPROVEMENTS TO NAVIGATION ENVIRONMENTAL STUDIES

Report	Authors	Affiliation
Wetland Habitat Mapping	Nelson, Kalinowski & Lynam	Wash. Dept. of Game
Preliminary Ocean Disposal Study	Smith, Messmer, Phipps, Samuelson & Schermer	Grays Harbor College
Water Quality & Circulation	Loehr & Collias	Dept. of Oceanography, Univ. of Wash.
Fish Abundance, Distribution & Feeding	Simenstad & Eggers	Fisheries Research Inst., Univ. of Wash.
Dungeness Crab Mortality	Stevens	Wash. Dept. Fisheries & College of Fisheries, Univ. of Wash.
Crab Feeding & Shrimp Distribution & Abundance in Grays Harbor	Armstrong, Stevens & Hoeman	College of Fisheries, Univ. of Wash. & Wash. Dept. of Fisheries
Benthic Invertebrate Distribution, Composition & Abundance	Albright & Bouthilette	Wash. Dept. of Game
Dredging Modifications to Reduce Crab Mortality	Juhnke	Seattle District, Corps of Engineers
Corophium salmonis Population & Productivity	Albright & Armstrong	Wash. Dept. of Game & Univ. of Wash.
Primary Productivity of Aquatic Plants	Thom	Seattle District, Corps of Engineers
Wildlife Distribution	Kalinowski, Martin & Cooper	Wash. Dept. of Game
Cultural Resources Evaluation	Maas	Seattle District, Corps of Engineers
Endangered Species Evaluation	Brunner	Seattle District, Corps of Engineers
Upstream Sedimentation Sources	Kehoe	Seattle District, Corps of Engineers
Bioassay, Bioaccumulation Studies	Pierson, Tornberg, Nichols & Nakatani	Fisheries Research Inst., Univ. of Wash.
Klebsiella sp. Micro-Organism Study	Storm	Seattle District, Corps of Engineers
Sediment Chemistry Study	A.M. Test, Inc.	A.M. Test, Inc.
Distribution & Abundance of Salmonid Food Organisms in Grays Harbor	Cordell & Simenstad	Fisheries Research Inst., Univ. of Wash.
Distribution & Abundance of Shorebirds & Waterfowl in Grays Harbor During Spring Migration	Herman & Bulger	Evergreen State College
Grays Harbor Drifter Study	Schuldt	Seattle District, COE

See author's names in bibliography for complete report citations.

Continuation of the present annual maintenance dredging would have no measureable impact on terrestrial flora and fauna, wetlands, threatened and endangered species or historic and prehistoric structures or objects. This no-action alternative would not conflict with any existing plans, policies, or controls.

In summary, environmental impacts associated with the no-action plan would continue as outlined in table EIS 2-6. Under the no-action plan, Grays Harbor will continue to present hazardous navigation conditions for larger, deeper draft ships.

4.03 Alternative 2c: Recommended Plan.

a. Physical Impacts and Their Significance.

(1) Air Quality, Noise Levels, Climate, and Soil Conditions. There will be no significant impacts to the following parameters from project construction according to the recommended (REC) plan: air quality, noise levels, climate, and soil conditions. Impacts associated with this plan are summarized in table EIS 2-6.

(2) Estuarine Ecology.

(a) Dredged Material Disposal. Should this plan be implemented, dredged material will be discharged in the estuary at the South Jetty and a new Point Chehalis site. Table EIS 2-3 indicates the amount and type of material to be deposited at each site. Coarser material will be placed at both Point Chehalis sites and fines will be discharged at South Jetty.

If some of the dredged material is found to be unacceptable for open-water disposal, an upland area (currently used for storing logs) northwest of Cosmopolis (see plate 7 for location) may be diked and could receive up to 1 million cubic yards (c.y.) of dredged material.

(b) Estuarine Sedimentation. Dredged material discharged at the new Point Chehalis and South Jetty sites is expected to move seaward and sedimentation in the estuary should not be greatly influenced by dredged material disposal. The majority of silts and sands deposited at South Jetty and Point Chehalis is expected to be carried by the predominant ebb current seaward of the bar and enter the winter northbound littoral system. A small quantity may be carried into the estuary along the north jetty. Coarse sand material disposal at Point Chehalis will initially undergo spreading in all directions but is expected to remain in the deep thalweg off Point Chehalis. Ultimately the net flow will transport this material to the sea. Information on the movement of silt material is less well known. From bottom photographs and sediment sampling of the old disposal areas, it is evident that silts do not accumulate in this area. In addition, current data indicates the net movement will be seaward. However, flood currents are also of sufficient

strength to transport silts deposited at the sites although the extent and volume of landward movement is not known. The silts have been designated for South Jetty, the seaward most estuarine disposal site, (and in the ocean) to minimize the risk of fines transport to the inner estuary.

(c) Water Quality. Short-term impacts will occur due to temporary increases in turbidity, release of small concentrations of contaminants, and minor reduction of dissolved oxygen concentrations in the areas being dredged and at the disposal areas. The initial and operation and maintenance (O&M) dredging associated with this project will be conducted in accordance with the Washington Department of Ecology (WDE) Water Quality Guidelines for Dredging in Inner Grays Harbor and Lower Chehalis River to insure that the aquatic resources of Grays Harbor will be protected from substantial impacts due to the above changes in water quality.

Some of the contaminants present in the dredged sediment will be released into the water column and diluted over a period of time (reference elutriate chemical testing summarized in appendix A). Bioassay and bioaccumulation tests being conducted with sediments to be dredged during project construction have not indicated to date any reason for concern for fish and marine invertebrates exposed to these sediments (see exhibit 2 of appendix A).

Long-term water quality impacts associated with the new channel dimensions have been addressed by Loehr and Collias (1981). This study indicated that no long-term water quality impacts were expected. Minor changes in circulation, residence time, and salt wedge intrusion have been predicted. In addition, there will be a greater annual impact from our O&M dredging to the harbor water quality because the present average annual dredging quantities will be increased by an estimated 88 percent. The vast majority of this increased dredging will occur in the outer harbor (two-thirds of it will be sand from the outer bar) and water quality impacts are expected to be minimal.

(3) Ocean Ecology. Ocean disposal of the dredged material to be derived from construction of the Grays Harbor Navigation Improvement Project and subsequent maintenance dredging will require selection and formal designation of an ocean disposal site(s) within 8 miles of the mouth of Grays Harbor. The Corps of Engineers will examine several potential disposal areas, located between 2.5 and 8 miles from the estuary mouth, in a detailed study during the Continuation of Planning and Engineering (CP&E) phase of the project. The detailed studies will serve as the basis for site selection and designation and a more complete impact analysis. The REC plan proposes disposal at two sites, each located approximately 3.5 miles from the estuary. These sites were proposed primarily for purposes of estimating the cost of the REC plan. Additionally, 3.5 miles is the distance from the mouth of the estuary where some silts can be found in the bottom sediments, suggesting that

some of the discharged silts may be incorporated into the midshelf silt deposit and not be returned to shore. Actual disposal sites will not be selected until the CP&E phase. The potential disposal areas include sites in the nearshore sands (which occur between 0-130 feet water depth), the midshelf silt deposit (130+ feet water depth), and the relict gravels (deepwater west by northwest of the estuary mouth). The REC plan disposal sites (both 3.5 miles from the estuary) are located in the transition zone between the nearshore sands and the midshelf silts. Impacts of dredging on the outer bar are similar to those discussed in paragraphs 4.03a(2)(c) and 4.03b(2) and are not addressed below.

(a) Water Column Impacts.

1. Surface Water. Dredged material discharged from a bottom dump hopper dredge or barge will descend through the water column as a dense mass moving faster than the settling velocities of the individual sediment particles. The pycnocline (density discontinuity) during the proposed dumping period (May-October) is expected to be weak due to waves and wind-induced upwelling. As a result, the sediment mass is expected to reach the bottom without "collapsing" (breaking up). However, as the dense mass moves through the water column, currents will entrain water along the edges of the mass and sediment will spin off and slow down to settling velocity. The bulk of the discharge will impact the bottom as one mass. Sediment remaining in the water column will increase turbidity and levels of suspended solids. Coarser sediment (sands) will settle faster than finer sediment (silts) and is not expected to contribute turbidity to the surface waters above the normal range of ambient conditions. However, silts will remain in the water column to be distributed primarily south and away from land by the prevailing surface currents. Silts will be incorporated into the neuston (top 4-8 inches) layer and may be concentrated at the pycnocline. Upwelling during the proposed dumping period will contribute to the continued suspension of silts in the surface waters.

2. Bottom Water. Shear stresses on the falling dredged material mass would suspend and slow down some of the sediment particles near the edge of the sediment mass. Impact with the bottom will also suspend sediments. Currents in the bottom water during the proposed dumping period would be weak and highly variable to the north and towards land. Coarser particles would settle rapidly to the bottom and would likely stay put until stronger winter bottom currents and storm waves moved the sediment northward and onshore. Silts would stay in suspension for a longer period of time, primarily moving northward and towards land as part of the nepheloid (near bottom) layer. Once near land, waves and upwelling would move the silts to the surface water where they would move offshore and south. Long-term destination of these silts would be to settle out in deeper waters as part of the midshelf silt deposit. Only the finer particle sizes (silts) would result in increased, and possibly persistent, turbidity and suspended solids above the normal range of ambient conditions, primarily near the bottom. Continued use of the disposal site for discharge of maintenance dredged material will not significantly impact the pelagic environment due to the coarse nature of the sediments (sands).

3. Pelagic Chemical Impacts. Current and wave energy at the ocean disposal site, combined with relatively low levels of total organic carbon, volatile solids, and chemical oxygen demand in the proposed dredged sediments indicate that chemically induced changes in water column dissolved oxygen will not be measurable. Some of the contaminants present in the dredged sediment will be released into the water column and diluted over a period of time (reference elutriate chemical testing summarized in appendix A).

(b) Sediment Impacts.

1. Mounding Long-term changes in bathymetry at the disposal site are not anticipated as the bottom currents are expected to incorporate the discharged sediment into normal sediment circulation patterns. Short-term changes (1 to 3 years) may result in minor, localized variations in near bottom currents and in erosion, deposition and transport rates of sediment. The small quantity of maintenance dredged sands that would be discharged at the disposal site is not expected to produce persistent mounding.

2. Grain Size Changes. Increased amounts of silts above present conditions will occur in the disposal area and to the north of the site. These finer sediments will likely take several years to be completely removed from the predominantly sandy environment. Silts deposited in the mouth of the estuary (South Jetty disposal site) will be flushed into the nearshore ocean environment by tidal action. These silts will be incorporated into normal sediment circulation patterns along the coast.

3. Benthic Impacts. The proposed ocean discharge will increase organic carbon, volatile solids, and sulfides in the sediment of the disposal area. Increased concentrations of organic compounds will likely stimulate bacterial action resulting in localized pH decreases accompanied by release of hydrogen sulfide and contaminants (especially heavy metals) to the interstitial and nepheloid waters. These releases will likely be slow and temporary (lasting at most until winter storms disperse the primary sediment mound) and will be rapidly diluted.

b. Biological Impacts and Their Significance. The primary impact of this project involves habitat disruption and benthic population reductions. Both temporary and permanent impacts will occur. Some resident species will be displaced and killed. The following subsections discuss the significance of these impacts to significant resources in various habitats.

(1) Terrestrial Ecology. Upland disposal of dredged material will only occur if some of the sediments to be dredged from the harbor are determined unacceptable for open-water disposal. Chemical analyses of the Grays Harbor sediments indicate that these sediments are acceptable for open-water disposal and bioassay and bioaccumulation studies

are expected to confirm this. If some of the sediments are found to be unsuitable for open-water disposal, an upland area (presently a log storage yard, plate 7) would be utilized for disposal of that material. The vegetation at this site is already very disturbed, and impacts to terrestrial species from disposal would be minimal. There are no threatened or endangered species residing at the potential upland disposal site.

(2) Estuarine Ecology.

(a) Vegetation. The REC plan calls for disposal of the inner harbor silty sediments at the ocean and the South Jetty disposal sites while new Point Chehalis site will be used primarily for disposal of sands. These locations have been selected to minimize return of silty sediments to the harbor. In addition, the use of clamshell dredges in the inner harbor will minimize the release of contaminants near the dredge from the sediments more effectively than hopper or pipeline dredges.

The major impact on estuarine vegetation associated with the REC plan is a temporary, highly localized decrease in water quality. Increases in turbidity and contaminant concentrations and decreases in dissolved oxygen concentrations in the water will be associated with both dredging and disposal activites. However, these temporary water quality changes are not expected to have measurable impacts on the productivity of the estuarine vegetation.

Thom (1981) found that even with dredged material disposal occurring completely within the estuary (at Point Chehalis), reduction in phytoplankton and eelgrass productivity due to recirculation of material would not be substantial. Lands vegetated by marsh angiosperms will not be removed or otherwise measurably affected by dredging or disposal operations. Four acres of shallow subtidal containing benthic algae (i.e., diatoms, macroalgae) will be dredged and removed in the Cow Point (2 acres) and South Aberdeen (2 acres) reaches. This removal will reduce total estuarine benthic algal productivity by an insignificant amount (see Thom, 1981).

(b) Benthic Invertebrate Communities. Recent studies in Grays Harbor have focused on the impact of the widening and deepening project on infauna (Albright and Bouthillette 1981), epibenthos (Albright and Bouthillette 1981, Cordell and Simenstad 1981, Simenstad and Eggers 1981, Armstrong et al., 1981), and Dungeness crab (Armstrong et al., 1981). Benthic invertebrate communities are affected by removal, burial, and changes in water and sediment characteristics.

Channel dredging and dredged material disposal will be confined to depths greater than -15 feet relative to MLLW, except for 4 acres of shallow subtidal habitat near the South Aberdeen and Cow Point turning basins (see table EIS 2-1).

Within the harbor, the proposed dredging will disturb an additional 565 acres below MLLW beyond that presently affected by existing maintenance dredging. Benthic infauna and epibenthic organisms will be removed in areas dredged. Recolonization should occur in these areas shortly after dredging (Albright and Bouthillette, 1981). Initial recolonists will be opportunistic species (e.g., oligochaete and polychaete worms) followed in succession by longer-lived organisms (e.g., bivalve molluscs). Eventually, benthic assemblage structures (i.e., species abundances, biomass, diversity) will reach an equilibrium condition. Periodic disturbance of the assemblages by maintenance dredging will be restricted to shoaling areas. These areas are expected to occur in approximately the same locations as in the present channel.

Some relatively flat areas will be changed to channel side slopes which will alter the structure of the benthic assemblage. This change will most likely occur in the Moon Island reach where relatively flat, shallow areas exist very near the navigation channel. Data on assemblages near Moon Island indicate that the side slope assemblage has a greater mean species richness, total abundance, and biomass than the assemblage at MLLW. Corophium spp. amphipods are in relatively high abundance at both sites. The greater biomass and abundance on the channel side slope is attributed to greater abundances and species of polychaetes (Albright and Bouthillette, 1981). This change should benefit most larger predators that feed on benthic invertebrates. However, juvenile salmonids that prey on small epibenthic crustacea (e.g., harpacticoid copepods) in shallow muddy areas may be detrimentally impacted (see paragraph EIS 4.03b(2)(c).

Disposal of 9.9 million c.y. of dredged material at Point Chehalis and South Jetty will alter existing benthic community structure. The proposed Point Chehalis site is presently dominated by polychaetes, and it is expected that recovery of the area to a similar condition will occur following initial project construction. However, disposal of maintenance dredged material at this new Point Chehalis disposal site, especially that from the inner harbor, may result in a permanently altered community structure.

A well-developed coarse substrate assemblage dominated by barnacles presently exists at the South Jetty site. Disposal of finer grained sediments may change this assemblage to a soft bottom community probably similar to that at the Point Chehalis site. The depth of the site will be decreased. Rockfish are commonly caught by commercial and sport fishermen in this area, and alteration of benthic conditions would probably result in a decline in this fishery. Scouring is intense at this site, and it is expected that the site would recover to preproject conditions at some time in the future. However, disposal of maintenance dredged material at this site may permanently alter the bottom conditions in a portion of the disposal site.

Turbidity, siltation, and any toxic effects associated with dredging would extend to a limited degree into areas beyond the navigation channel. Some dredged material disposed at Point Chehalis and South Jetty may be carried back into the harbor. As with primary producers, this is expected to have a small and unquantified impact on benthic invertebrate assemblage structure. Bioassay and bioaccumulation tests will evaluate the potential for accumulation of contaminants in the tissues of some species. Species recolonizing the dredged material will be those tolerant of the sediments of the various grain sizes and containing low levels of some contaminants.

The REC plan proposes to avoid the entrainment of crabs through modification of dredging equipment. The basis for recommendation of this mitigation is contained in paragraph 4.03f below. The REC plan has scheduled dredging to avoid time of high crab densities in various reaches and has avoided disposal of silty materials in the harbor mouth when larval crabs are present in the water column. Burial of crabs by dredged material disposed at Point Chehalis, South Jetty, and at the ocean site would result in some reductions in numbers of larger crabs. Crab fishing does occur near South Jetty, and disposal of dredged material may reduce crab catch in the vicinity of the disposal site during the times when disposal is taking place.

Losses to the crab population due to reduction in the reproductive population may also be important. However, estimates of this impact are difficult to make in view of the possible corresponding decrease in cannibalism and intraspecific competition. Other indirect impacts that may affect crab populations include temporary removal of food sources from dredged and disposal areas, alteration of intraspecific, competitive, and cannibilistic interactions due to size selective mortality during dredging, potential alteration of a minimal amount of habitat due to the recirculation of some sediments back into the harbor, and water quality impacts on larvae and adults. The bioassay tests described in exhibit 2 of appendix A address the water quality impacts, but these other indirect impacts are unquantifiable and are not expected to be substantial. Water quality impacts to crab larvae are not expected to be significant based on preliminary indications of bioassay test results.

(c) Fish. Studies assessing the impact of the dredging project on fish utilizing the estuary were primarily concerned with fish entrainment by dredges (Armstrong et al., 1981) and degradation of the habitats of juvenile salmonids and baitfish (Simenstad and Eggers, 1981).

Eleven species of fish were entrained in hopper dredges working in the South reach, Crossover reach, North Channel, and Cow Point reach (Armstrong et al., 1981) (table EIS 4-2). Using the summer entrainment rates for each species as a worst case estimate (Stevens (1980) recorded lower rates for fish in winter) for the entire year, approximate entrainment levels for hopper dredging quantities were calculated (table EIS 4-2). No fish were entrained by clamshell dredges during a previous study

(Stevens, 1980) although Pacific sand lance have been taken up by clamshell dredges in other dredging projects. The recommended plan has scheduled dredging to avoid times of high fish densities in the upstream reaches. Modification of hopper dredges to avoid crab entrainment should beneficially affect the entrainment of fish; however, the extent of the change in entrainment is unknown. Additionally, water quality impacts will be minimized by the use of clamshell dredges in these reaches.

TABLE EIS 4-2

ENTRAINMENT OF FISH BY HOPPER DREDGES
UNDER THE REC, NED, and LED PLANS1/

Based on entrainment rates in Armstrong, et al., 1981)

Fish Species	Number of Fish Entrained REC Plan	NED Plan	LED Plan
Staghorn sculpin	410,000	440,000	331,000
Pacific sanddab	282,000	282,000	274,000
Pacific tomcod	23,000	23,000	0
Snake prickleback	23,000	23,000	0
Saddleback gunnel	18,000	18,000	18,000
English sole	126,000	126,000	126,000
Northern anchovy	64,800	64,800	64,800
Sand sole	10,800	10,800	10,800
Speckled sanddab	10,800	10,800	10,800
Lingcod	7,200	7,200	7,200
Pacific sandfish	7,200	7,200	7,200

1/Entrainment rates reported in this table do not take into account the changes in fish entrainment that may result from dredge modifications to avoid crab entrainment.

Habitat degradation may be divided into the major categories of decreased water quality and loss of feeding and rearing habitat. Data from trawl samples taken near the working dredge suggest that some fish species (i.e., buffalo sulpin, longfin smelt, Pacific herring, starry flounder, and shiner perch) were actively avoiding the dredge (Armstrong et al., 1981). Avoidance of areas by juvenile salmonids or other fish of increased turbidity around dredges in Grays Harbor was not documented by Simenstad and Eggers (1981). However, they stated that release of substantial amounts of contaminants from sediments could produce an avoidance reaction in the region of the plume created by dredging. Such an effect would only last as long as the plume was present. Most outmigrating juvenile salmonids utilize the estuary from February through July. Under the REC plan, dredges will be working in several areas of the channel simultaneously throughout the year. The plume areas around the dredges will probably be avoided by outmigrating salmonids. This

prolonged activity could effectively eliminate a minor portion of shallow sublittoral or neritic rearing habitat normally utilized by juvenile salmonids. Strict avoidance reaction caused by dredges should not measureably alter salmonid populations and migration patterns through the estuary. Impacts of contaminants which may be released through dredging or disposal activities on juvenile fish is currently under investigation using bioassay experiments.

Approximately .89 percent of the total sublittoral area will be disturbed during the project (with little overall loss in total estuarine bottom surface area). A total of 4 acres of shallow subtidal habitat in the inner harbor will be changed to deeper, and less valuable, subtidal habitat. Salmonids may utilize alternative areas if they are available (i.e., if the habitat area is not now limiting fish production). The proposed mitigation should allow replacement of this lost habitat. Simenstad and Eggers (1981) concluded that, due to their specialized utilization of benthic areas, English sole may be impacted somewhat more than salmonids. This issue will be further investigated during CP&E. Baitfish populations should not be affected.

Disposing dredged material at the Point Chehalis and South Jetty disposal sites will result in a loss of rockfish habitat. O&M dredged material disposal will impact this habitat for the life of the project. Rockfish represent an important sport and commercial resource in this reach which may be temporarily displaced from this habitat due to dredged material disposal.

(d) Avian Fauna. Impacts of the REC plan to shore birds will be negligible. A very small part of the 4 acres of shallow subtidal habitat which will be lost in the inner harbor is low intertidal. Therefore, shore birds will have slightly less feeding habitat available in the inner harbor. This loss should be compensated by the proposed mitigation.

A temporary increase in turbidity from dredging and disposal operations may make capture of prey by fish-eating species of water birds (such as grebes, mergansers, and Caspian terns) difficult. However, these birds, and the fish they feed upon, are highly mobile and might be expected to avoid turbid areas. Thus, impacts to waterfowl from turbidity are expected to be minimal under the REC plan.

(e) Marine Mammals. The impacts to marine mammals with the recommended project construction plan will be minimal. The physical dredging of Grays Harbor should not directly impact any marine mammals in the harbor. No seal haul-out areas will be impacted. The transport of dredged material to the in-harbor and ocean disposal sites will occur every few hours and will be concentrated in a narrow corridor (the navigation channel and towboat lanes) and is not expected to affect marine mammals in either the harbor or the ocean. The food sources of marine mammals living in or passing by Grays Harbor will not be substantially reduced by the REC plan.

(3) Ocean Ecology. Though continental shelf areas are known to be highly productive for marine fisheries, ocean disposal of dredged material is not likely to affect as many critical ecological processes as would occur with disposal in the estuarine environment. This is primarily due to the high energy dilution potential of the shell zone and the consequently relatively transitory effects to the pelagic environment. Long-term impacts to the benthos will occur at the ocean disposal site which receives maintenance dredged material from the outer bar. Impacts of dredging on the outer bar would be similar to those discussed in paragraph 4.02b(2)(b).

(a) Flora.

1. Phytoplankton. Increased turbidity will result in reduced light penetration and reduced productivity of phytoplankton in the euphotic zone. Phytoplankton in the path of the dredged material mass or settling sediment will be removed from the euphotic zone and lost (flocculated). The release of nutrients and growth inhibitory or stimulatory substances from the dredged material may occur, but it would be in concentrations insufficient to produce persistent effects. All of the above impacts are not expected to be measurable at the edge of the disposal area. Duration of the impacts would be short term (minutes to hours).

2. Other Primary Producers. Benthic primary producers are absent at or near the proposed ocean disposal sites due to the lack of stable substrata. Consequently, the proposed discharge will not impact other primary producers.

(b) Invertebrate Fauna.

1. Zooplankton. Increased suspended solids in the water column as a result of the proposed discharge will interact with zooplankton in several ways. The suspended solids will dilute the concentration of food particles in the water for filter feeders. Flocculation of phytoplankton will also reduce food availability. Microscale changes in the distribution of pelagic, near-bottom larvae may result from mounding-induced current changes. All of the above impacts are expected to be measurable only at or near the actual discharge site. The meroplankton (including pelagic larvae of fish and shellfish) are known to be acutely sensitive to dissolved oxygen changes and increased levels of contaminants in the water. Preliminary results of biological tests underway at the time of this writing suggest that toxic effects to meroplankton would not occur during disposal.

2. Benthic Epifauna. Some epifauna in the disposal area will be buried and lost as a result of the discharge. Increased suspended solids near the bottom will displace the more mobile species as they avoid the site. Organisms not avoiding the discharge and plume will be temporarily stressed. Burial of benthic infauna will reduce food supply

of some marine organisms. Suspended solids will dilute the food value of the nepheloid layer to filter feeders. These physical effects will be limited to the discharge site and primary plume of the dredged material. Chemical effects of sediment contaminants on benthic epifauna are being addressed by the ongoing biological tests. Chemicals released into the water column may result in an avoidance response from crab and shrimp species and/or possible impairment of normal feeding behavior (due to chemical interferences). The extent of this latter impact is unknown.

3. Benthic Infauna. Infauna at the discharge site will be buried by the dredged material. More mobile species near the edge of the discharge mound should be able to survive the burial as long as they are tolerant of the increase in fine particles. Recolonization of the sediment at the disposal site will occur first by those species that are tolerant of silts and later (as silts are winnowed from the site) by most of the species present at the site prior to disposal. Silts moving along the bottom will suffocate those organisms near the disposal site that are less tolerant of finer particle sizes. Suspended sediment will dilute the food value of the nepheloid layer to filter-feeding infauna. Sediment mounding will increase structuring of the benthic environment. This structuring, along with increased fines and organic enrichment, may likely result in temporarily increased infaunal biomass and species diversity after recolonization of the sediment has occurred. However, overall organism abundance is expected to decrease. The above effects are limited in extent to the areas within or near the disposal site. Continued use of the site for disposal of maintenance dredged material would result in some persistent changes to the infauna. Effects of sediment contaminants on the benthic infauna are being addressed by ongoing biological tests.

(c) Fish.

1. Pelagic Fish. The proposed discharge will add suspended solids and turbidity to the water column, affecting pelagic fish, including migrating salmonids (both juvenile and adult). Most individuals are expected to avoid the turbid plume. Those that do not avoid the plume will be temporarily stressed and may suffer sublethal respiratory impairment due to sediment effects on the gills. Since the severity of these effects is primarily a function of sediment particle angularity rather than overall suspended sediment levels, and since the Grays Harbor sediments are predominantly well rounded (low angularity), persistent or lethal effects to pelagic fish are not anticipated. Physical interference with feeding behavior may also occur. All of the above impacts will be temporary and limited to the disposal area and primary discharge plume. Effects of sediment contaminants on anadromous fish are being investigated during biological testing of the dredged material.

2. Demersal Fish. As with pelagic fish, most fish species and individuals are expected to avoid the disposal area and surrounding water with high concentrations of suspended solids. Though temporary

physical stress is likely, mortality resulting from sediment impacts to respiratory surfaces is not expected. Loss of benthic organisms will reduce the availability of food at and near the disposal site. Grain size induced changes in benthic community conposition may either increase or decrease the value of the recolonized disposal area to certain species of bottom feeding fish. Disposal sites receiving maintenance dredged sands will be of lower value to demersal fish in the long term. Chemical releases from the sediment mound may cause an avoidance of the disposal area by certain fish species for a short period of time (not to exceed 1 year). Chemical contaminant effects of the proposed discharge on demersal species of fish are being addressed by the ongoing biological tests.

(d) Avian Fauna. Direct impact to birds from disposal of dredged material at the ocean sites is expected to be minimal. Birds are expected to avoid feeding in the plume created by disposal activities since their visibility and feeding success in this area would probably be reduced. These impacts will be temporary and will occur in a relatively small area of the ocean near Grays Harbor.

(e) Marine Mammals. Marine mammals will experience the same minimal impacts described above for birds.

c. Threatened and Endangered Species. Three biological assessments (BA) have been prepared on the threatened and endangered species known to occur in the Grays Harbor area. These assessments covered: (1) seven endangered whale species and the endangered Pacific leatherback sea turtle observed near Grays Harbor, (2) the peregrine falcon subspecies and bald eagle, and (3) the brown pelican. Each of these assessments concluded that no adverse impacts to these species would result from the proposed dredging and disposal as proposed under the REC plan.

The above BA's, which are on file at Seattle District, Corps of Engineers, were mailed to the responsible Federal agencies as required by Section 7 of the Endangered Species Act of 1973, as amended. The National Marine Fisheries Service (NMFS) has concurred with the above conclusions regarding the whales and sea turtle and the U.S. Fish and Wildlife Service (FWS) has concurred with the above conclusions regarding the peregrine falcon, bald eagle, and brown pelican.

d. Historic and Prehistoric Impacts and Their Significance. No impacts are expected. Refer to paragraph 3.02c for complete discussion.

e. Socioeconomic Impacts and Their Significance.

(1) Economy. Widening and deepening the Grays Harbor Channel is not expected to immediately stimulate expansive growth of the economy. Employment is not expected to increase as a direct result of the improved navigation project unless industry expands. The cost for shipping out of Grays Harbor will be decreased.

(2) Navigation. Hopper dredge and barge operations are anticipated to result in minor interferences with small craft navigation, especially in the vicinity of the bar and estuary mouth during peak recreational and commercial fishing periods. Disposal of dredged material in the ocean will not result in additional shoaling on the outer bar due to the fact that sediment transport in the ocean is energy limited. However, disposal in the estuary mouth is expected to require redredging of some of the material as it settles in the bar crossing. Redredging is less costly than taking the material directly to the ocean, and as long as the bar crossing is maintained regularly, adverse effects to navigation due to shoaling on the bar will not occur.

(3) Fisheries. As mentioned above, most of the potential ocean disposal sites are located in the navigation lanes to avoid direct impact to bottom fisheries (primarily crabbing done in shallow water). Additionally, the existence of energy limited sediment transport suggests that the discharge would not result in additional loss of crab pots due to dredged material shoaling. However, it is possible that the sediment mound and fine grain size will sufficiently change erosion conditions such that pots near the site are impacted. This effect would be more probable in shallower water (where currents are higher, sediment mounding is more likely and pots are more numerous). Additionally, avoidance of chemicals released from the dredged material may reduce the catch of pots located near the disposal area. Avoidance of the disposal is not expected to persist through one winter season. Mitigation proposed as part of the REC plan should result in avoidance of this impact.

f. Relationship of Recommended Plan to Existing Plans, Policies, and Controls.

(1) Existing Land Use. Existing land use in the project area consists mainly of industrial facilities, log storage areas, and shipping terminals on the north shore of Grays Harbor from the Hoquiam reach upstream to Cosmopolis (channel reaches are identified in plate 1). The Bowerman Airport is located at the eastern end of Moon Island reach. The remainder of the channel is flanked by intertidal and subtidal vegetated and unvegetated mudflats from the Cow Point reach to the harbor mouth. The Westport boat basin is located on the south side of the channel near Point Chehalis and the channel is flanked by the North and South Jetties as the navigation channel joins the ocean.

Land use in the project area is controlled primarily by city and county zoning ordinances. Wetland areas near Junction City and on the southern shore of Grays Harbor by Cow Point may become more valuable after the navigation channel improvements are completed due to their proximity to the wider and deeper navigation channel and would be under increased pressure for development. Disposal of sediments in the Point Chehalis area and along the South Jetty will not change present land use patterns near the mouth of Grays Harbor.

(2) Coastal Zone Management Act. The National Coastal Zone Management Act (Public Law 91-583: 86 Stat. 1280) was passed by the United States Congress in 1972 and in June 1976 the state Coastal Zone Management Program (CZMP) was approved to receive funding. The Washington State Shoreline Management Act (SMA) of 1971, as passed by the State Legislature, provides "for the management of Washington's shorelines by planning and fostering all reasonable and appropriate uses." The SMA is implemented through Shoreline Master Programs (SMP) for large municipalities and the counties. The project would be consistent with all applicable Grays Harbor SMP's and so satisfies consistency with state and national coastal zone management requirements.

(3) Grays Harbor Estuary Management Plan. During the fall of 1975, the Grays Harbor Regional Planning Commission initiated a program designated to produce a Grays Harbor Estuary Management Plan (GHEMP). Funding for the development of the GHEMP was provided from the Office of Coastal Zone Management under the auspices of Section 306 of the Coastal Zone Management Act. A preliminary draft of the GHEMP, when finalized and incorporated into Shoreline Master Programs, dated November 1978, has been made available for review. Filling of the upland disposal area (plate 7) which is available (if any material is found to be unacceptable for open-water disposal) would be in conformance with GHEMP. An additional disposal area which is not presently part of the recommended plan (or any other plan) but which might become available for use when the GHEMP becomes finalized is the area immediately north, west, and south of the Bowerman Airport (plate 7). The GHEMP, when finalized and incorporated into the Shoreline Master Programs, may allow some filling in areas near the airport. These areas are heavily used by shore birds and appear very important to an endangered subspecies of the peregrine falcon. The FWS has determined that some filling in these areas would not jeopardize the continued existence of the peregrine falcon and that filling these areas will have acceptable environmental impacts considering the protection afforded the remainder of the estuary by the GHEMP. To insure that the endangered peregrine falcon is not adversely affected, the FWS has proposed that a monitoring program be conducted prior to, during, and after placement of fill in these areas. The use of these areas as disposal sites for this plan will be further evaluated after the GHEMP is finalized (during the CP&E phase of the proposed channel improvements). Dredging the navigation channel and disposing of this material in the proposed in-harbor, open-water disposal sites are permitted activities under the GHEMP.

(4) Department of Natural Resources Policy on Open-Water Disposal of Dredged Material. Sites throughout the marine waters of Washington have been designated as open-water disposal areas. If dredged material cannot be constructively utilized (i.e., creation of artificial islands, landfill), and it is approved by all of the various regulatory agencies for open-water disposal, it may be deposited in the Department of Natural Resources (DNR) managed sites. The proposed South Jetty and Point Chehalis disposal sites are expected to be approved by DNR and the

DNR-chaired Interagency Open-Water Disposal Site Selection Committee. Assuming these sites will be approved, the project is consistent with DNR dredged material disposal policies.

(5) Clean Water Act of 1977, Section 404(b)(1). In compliance with the Clean Water Act, Public Law 92-500, as amended, a Section 404(b)(1) evaluation of the impacts of disposal of dredged material at Point Chehalis and South Jetty associated with the REC plan has been completed and is attached as appendix A. Pursuant to Section 404(r) of the Clean Water Act, upon submittal of this EIS with its complete 404(b)(1) evaluation to Congress and its approval by Congress, no further action to meet the requirements of the Clean Water Act will be necessary. Thus, State Water Quality Certification per Section 401 will not be required.

(6) The Marine Protection, Research and Sanctuaries Act (MPRSA) of 1972 (Public Law 92-532). Commonly called the Ocean Dumping Act, the MPRSA and implementing Environmental Protection Agency regulations (40 CFR Parts 220-229) govern the disposal of dredged material in the territorial seas of the United States. Primary requirements of the act and regulations relate to determining acceptability of the dredged material for disposal in the ocean and to locating and formally designating an ocean disposal site. Acceptable dredged material to be derived from the Grays Harbor Improvements to Navigation project is being identified during the feasibility stage of project study by conducting biological testing with the proposed dredged material. Description of the testing is contained in appendix A. Studies to locate a suitable ocean disposal site will be conducted during the CP&E phase of project study. Potential disposal sites to be studied are shown in plate 7. An EIS supplement will be prepared during CP&E to complete formal designation of the ocean disposal site. Consequently, compliance with the MPRSA will be completed during CP&E.

(7) Water Resources Development Act (WRDA) of 1976 (Public Law 94-587). In accordance with the requirements set forth in Section 150 of the WRDA of 1976, a determination was made regarding the feasibility of establishing wetland areas by using dredged material. Several wetlands establishment sites were evaluated and biological studies were begun at one site during 1981. All studies were terminated when the local sponsor withdrew the site and offered no alternate sites. The establishment of wetlands with dredged material in Grays Harbor will be evaluated further during CP&E studies or by the Grays Harbor operation and maintenance program if suitable sites become available.

(8) Executive Order 11988, Flood-Plain Management. Executive Order 11988 defines acceptable management of areas located within flood plains. The plan for improvement lies entirely within the area of tidal influence. Riverine effects do not influence the base flood elevation. Four acres of shallow subtidal habitat in the inner harbor will be changed to deeper subtidal habitat (channel side slope) and mitigated by

purchasing nearby uplands adjacent to the harbor and converting them to intertidal or shallow subtidal. If the sediments to be dredged prove to be unacceptable for open-water disposal, the 51-acre upland site northwest of Cosmopolis (plate 7) will be used for disposal of this material. Impacts on the flood plain from the project dredging and disposal activities would be negligible.

During the planning process for the proposed project, Federal, state, and local agencies; organizations; and the public have been kept informed of the proposed action, including the dredged material disposal plan, through a series of interagency meetings, workshops, news releases, and public newsletters. Environmental effects of the proposed action are presented in this EIS. This process satisfies the requirements for the decisionmaking process of Executive Order 11988.

(9) Executive Order 11990, Protection of Wetlands. The intent of Executive Order 11990 is to protect wetlands because of their high value to biological productivity. Although plans for improvement would cause removal of 4 acres of shallow subtidal habitat along the waterways, which may be considered wetlands by some, this would be mitigated by construction of similar shallow subtidal habitat. Therefore, based on previous analysis made in accordance with section 2a of this Executive Order, it is determined that no practicable alternative to the proposed alteration exists, and that the REC plan includes all practicable measures to minimize losses to wetlands as a result of construction. The project would be in compliance with Executive Order 11990.

g. Mitigation of Adverse Effects.

(1) Recommended Plan Mitigation. Mitigation actions for two significant, adverse impacts of the navigation channel improvement project have been included as part of the REC Plan. First, REC plan includes replacement of 4 acres of shallow, subtidal habitat that would be lost due to initial channel widening in the Cow Point and South Aberdeen reaches. Replacement will be accomplished by purchasing a diked area along the bank of the Chehalis River (at about River Mile 1.8) and restoring this area to subtidal and intertidal habitat of use to migrating juvenile salmonid fish. Second, the REC plan includes modification of hopper dredges to avoid entrainment of Dungeness crabs. Detailed investigation of dredge modifications and their success in avoiding crab entrainment will occur during the CP&E phase of the project (see paragraph 4.33 of the feasibility report). If avoidance of the crab loss through dredge modifications is not feasible, other measures to mitigate for the loss will be evaluated and selected. These other measures could include: increasing natural survival of Dungeness crabs in Grays Harbor through selective redistribution; habitat enhancement to increase carrying capacity of the estuary; and the increased use of clamshell dredging to reduce crab mortality. The decision to investigate these other measures will be made based on the CP&E modification studies. Cost of the proposed mitigation actions is estimated at $550,000. The cost of

implementing an alternative measure to restore lost crabs is estimated at $1,500,000. The cost of further use of clamshell dredges (i.e., an avoidance alternative) would be substantially higher.

If avoidance of crab entrainment is not feasible, impact to the crab resource would result from use of hopper dredges. Implementation of an alternative measure to mitigate for lost crabs should avoid an impact to the crab fishery. If avoidance is possible and continues to be feasible for future maintenance dredging, the net impact of the channel improvement project may be beneficial by reducing or eliminating the crab entrainment presently associated with maintenance of the existing channel.

(2) Basis for Crab Mitigation. The REC plan proposed to avoid the entrainment of crabs through modification of dredges. The basis for proposal of this mitigation is contained in the following impact analysis. This analysis represents an evaluation of project impacts without mitigation. Dredge entrainment during initial construction of the REC plan could result in a reduction to the Dungeness crab harvest in Westport by an estimated .92-3.17 percent (project net impact) per year if proposed mitigation was not implemented. Although this is a 2-year construction project, impact would be realized over a 4-year period with the most significant impact occuring in the third year after initiation of project construction. Present maintenance dredging reduces the Westport crab fishery catch by an estimated 0.84 percent per year. Proposed maintenance dredging would result in an estimated additional, annual 1.71 percent impact for life of project. Including the outer bar, approximately 1 million crabs (of various age classes) will be killed during initial widening and deepening each year.

Dredge entrainment rates (number of crabs per cubic yard dredged) for various dredge types and population estimates presented by Armstrong et al. (1981) allow the above estimates of crab mortality caused by initial and maintenance dredging operations. The values of crab mortality were calculated using the following formula:

$$L = (V)(E)(M)$$

where,

L = number of crabs lost,

V = volume of material dredged by hopper or pipeline dredge in each reach, during each season,

E = entrainment rate for each dredge type, each reach, and each season, and

M = proportion of crabs entrained that are killed, which varies by the size of the entrained crabs.

Armstrong et al., calculated that there would be a 26 percent (on the average) reduction in entrainment if all dredging occurred at night. Since approximately one-half of dredging will occur at night, L was multiplied by 0.87 (i.e., 0.5 x 0.26 = 0.13; 1.00 - 0.13 = .87).

The number of crabs lost to the fishery was estimated using the formula:

$$F = L \times P_A \times P_M$$

where,

F = number of crabs lost to the fishery,

P_A = proportion of the killed crabs within each age class,

P_M = the proportion of each age class that would reach the fishery (i.e., not die naturally).

Based on Armstrong et al., (1981) the following values were used:

Age Class	P_A	P_M
0+	0.25	0.20
1+	0.50	0.50
2+ and older	0.25	0.80

The percentage of the Grays Harbor population that would be expected to reach the fishery without the project was estimated by multiplying population estimates for each year class for summer by expected survival (P_M). The summer population estimate was used because most hopper dredging in the reaches which contained the greatest number of crabs would occur largely in the summer. According to Armstrong et al. (1981) the best estimate for the summer population of crabs calculated for Grays Harbor estuary is 29,700,000. The population is composed of three age classes where 19,765,140 are 0+, 3 percent or 891,000 are adults, and 9,044,000 are 1+ to 2+ (juveniles). Based on the summer population and given the above natural mortality for each age class, the estimate for total number of crabs available to the fishery from the estuary is 9,187,000. As stated previously, approximately 1 million crabs per year would be killed during the initial project (2 years of initial construction dredging). This represents a loss of 517,000 crabs per year (F) to the number available to the fishery. The project impact to the total crabs available to the fishery is determined by dividing F by 9,187,000. This would result in an initial project construction loss of 5.63 percent per year to the total number of crabs available to the fishery. However, as explained below, this annual impact is spread over three years due to the year classes of entrained crabs.

Grays Harbor estuary may contribute as much as 80 percent of the local (Westport landings) offshore crab fishery (Armstrong et al, 1981). The actual catch landed in Westport ranges from an estimated low of 500,000

to a normal high of 3,000,000 crabs per year. Therefore, the Grays Harbor estuary may contribute as much as 400,000 to 2,400,000 crabs per year to the crab fishery landed at Westport. By allowing for the year classes of entrained crabs (which spreads the fishery impact of 1 year over 3 years), we estimate that initial construction could impact the annual crab catch by an estimated .92 to 3.17 percent and annual maintenance dredging by an estimated 1.7 per year for the life of the project. Table EIS 4-3 shows how initial dredging for two years affects the impact to the fishery for the first 2 years of postconstruction maintenance dredging. Similarly, the value of this impact can be estimated by assuming an average price of crabs ($1/pound or $2/crab) and multiplying by the Westport catch range and by the percent impact to the catch. Table EIS 4-3 shows that the value of this impact has been estimated to very between $9,160 and $190,380 per year for the 2 years of construction and first 2 years of maintenance dredging. Value impact of future maintenance dredging is estimated to vary between $17,100 and $102,600 per year, in addition to the impacts of existing maintenance work.

The above analysis does not address several key points that need to be mentioned here:

o Reproductive and related impacts to the crab resource have not been quantified.

o The mitigation proposed for the REC plan should result in avoidance of direct impacts to the crab resource.

o Impacts to the crab fishing catch and value described above do not take into account the all-male crab fishery, primarily due to the substantially higher number of male crabs entrained by the dredge (Armstrong et al., 1981) and the difficulty in addressing reproductive losses.

o Trawl data compiled by Armstrong et al. (1981) has been corrected for known sampling inefficiencies in order to arrive at total estuary population estimates. However, entrainment data could not be modified by any known sampling inefficiencies. Consequently, entrainment estimates for smaller crabs could be substantially underestimated.

h. Adverse Environmental Effects Which Cannot Be Avoided.

(1) Dredging. Dredging associated with this project will remove and destroy sessile and motile species of macroinvertebrates along the navigation channel. Some of these invertebrates are important food sources for sport and commercial fish species in Grays Harbor and others, such as the Dungeness crab, are important commercial species. Impacts to the Dungeness crabs in Grays Harbor will be mitigated through either dredging equipment or scheduling modifications to be determined during CP&E studies. Four acres of shallow subtidal fish feeding and rearing

TABLE EIS 4-3

SUMMARY OF PROJECT IMPACTS TO CRAB FISHERY OVER 5 YEARS

Impact		O&M Existing	Initial		O&M Proposed		
		0	1	2	3	4	5 1/
Available to Fishery (Crabs x 10^3)	Net 2/	0	105	316	355	223	157
	Total 3/	96	201	412	451	319	253
Catch at Westport 3/ (Crabs x 10^3)	Net 2/	0	4.58-27.5	13.73-82.35	15.87-95.19	10.99-65.94	8.55-51.3
	Total 3/	4.2-25.2	8.78-52.65	17.93-107.55	20.07-120.39	15.19-91.14	12.75-76.5
Value at Westport 5/ ($ x 10^3)	Net 2/	0	9.15-55.	27.46-164.7	31.74-190.38	21.98-131.88	17.1-102.6
	Total 3/	8.4-50.4	17.56-105.3	35.86-215.1	40.14-240.78	30.38-182.28	25.5-153.

1/Represents the typical impacts due to O&M for life of project.
2/Total minus existing maintenance dredging, net project impact.
3/Includes existing O&M.
4/Expressed as range based on catch range 500,000 to 3 million x percent impact to catch.
5/Expressed as range loss to fishery based on average $2/crab x impact on catch.

area in the inner harbor will be changed to deeper subtidal habitat through dredging but will be mitigated by converting nearby uplands to intertidal or shallow subtidal habitat.

Some minor, temporary decreases in water quality will occur in the areas immediately surrounding the dredging.

The REC plan attempts to minimize the impacts to crabs, fish, and water quality through careful scheduling of the dredging period and equipment to be used in each reach.

(2) Disposal. The material to be disposed from dredging activities would temporarily affect benthic invertebrates at the disposal sites. Some organisms would be eliminated, but with time, recolonization of the dredged material with invertebrates would occur. Commercial fishing in the disposal areas would be temporarily interrupted by disposal activities. Some minor, temporary decreases in water quality will occur at and near the disposal sites.

i. Irreversible and Irretrievable Commitments to Resources. The capital and labor necessary to dredge the channel will be committed irreversibly and irretrievably. This includes the capital and labor associated with dredging and disposal activities, administration, personnel, operations, maintenance, and petroleum products used. In addition, intertidal lands to be dredged and materials used will be irreversibly committed. Restoration of the substrate and reuse of discharged dredged material will not be possible.

j. The Relationship Between Local Short-Term Uses of Man's Environment and the Maintenance and Enhancement of Long-Term Productivity. The REC plan will enhance commercial and industrial shipping opportunities in the local area by providing more efficient means of transporting goods. Several acres of intertidal and shallow subtidal area will be removed but will be mitigated. Dredging and dredging-related activities may have a substantial impact on the crab population which could impact the overall commercial crab fishery in the Grays Harbor area. Therefore, mitigation of this impact is recommended and proposed.

Residents' income of some areas of Grays Harbor are dependent on the commercial crab fishery yearly catch. The reduction of the crab population may have an adverse effect on the annual number of crabs landed in years succeeding project construction. The full extent of project mitigation needed to avoid impacts to the fishery, will be established during CP&E studies.

4.04 Alternative 2a: National Economic Development Plan. The NED plan would be the same as the REC plan in terms of channel dimensions, dredging quantities, the characteristics of the dredged material, railroad bridge construction, the acres of shallow subtidal habitat lost, and the

type of mitigation recommended. For these reasons, socioeconomic, cultural, and many other types of impacts would be the same as those discussed for the REC plan (section 4.02).

The major engineering differences between the NED and REC plan include dredging equipment to be used and the location of disposal sites. The NED plan would use a pipeline dredge in the South Aberdeen reach and would dispose of most of this material at a nearby upland site (presently a log storage area). A clamshell dredge would also be used to dredge any remaining material from this reach which would exceed the capacity of the upland site.

All material destined for open-water disposal, with the exception of that from the outer bar and Aberdeen reaches (which would be discharged at an ocean disposal site about 2-1/2 miles from the harbor mouth), would be disposed within the harbor at the Point Chehalis and South Jetty sites.

The dredging schedule under the NED plan would be generally established for cost efficiency in overall project dredging rather than for environmental protection. Therefore, some impacts to the large concentrations of outmigrating juvenile salmonids might be expected during inner harbor dredging. These impacts could be from direct entrainment by the pipeline dredge or from water quality degradations associated with dredging. Dungeness crabs and marine fish entrained and killed by project construction could be greater than under the REC plan and would require greater mitigation efforts. Direct dredging related impacts to smaller invertebrates in the sediments will be similar to those associated with the REC plan.

Water quality impacts during dredging will be similar to those associated with the REC plan. Water quality in the mouth of the harbor would be temporarily degraded by the disposal of the majority of the inner harbor silts at the South Jetty site. Turbidity and contaminant concentrations in the water column would temporarily increase and dissolved oxygen concentrations would decrease. While the materials to be discharged at these two inner harbor sites would ultimately be swept from the harbor, some recirculation and sedimentation on eelgrass beds, oyster beds, and various benthic organisms (such as larval Dungeness crabs) would be likely to occur.

Ocean impacts associated with the NED plan would probably be less than those expected with the REC plan since less material would be disposed directly in the ocean. However, the use of a nearshore site could potentially impact the clam resource and the crab fishery. While the material discharged in the harbor mouth will be scoured from the disposal areas, it will reach the ocean as a thin sheet and cause minimal environmental impacts. The ocean disposal site would be chosen to minimize biological and commercial fishing impacts in the ocean and minimize return of sediments to Grays Harbor and ocean beaches.

Ocean disposal of dredged material under the NED plan would be substantially reduced in quantity (especially the siltier material). As a result, the potential for direct water quality and chemical impacts to the ocean environment is also reduced. However, the disposal of the dredged material in the mouth of the estuary and closer to shore would result in increased potential for resuspension of fines in the estuary. A high potential for shoaling of crab pots and avoidance induced reduction in catch would exist due to the proximity of areas with high density fishery activity.

4.05 Alternative 2b: Least Environmentaly Damaging (LED) Plan. The LED plan would be the same as the REC plan in terms of channel dimensions, dredging quantities, the characteristics of the dredged material, railroad bridge construction, the acres of shallow subtidal habitat lost, and the types of mitigation recommended. For these reasons, socioeconomic, cultural, and many other types of impacts would be the same as those discussed for the REC plan (section 4.02).

The major difference between the LED and REC plan include dredging equipment to be used and the location of disposal sites. Under the LED plan, clamshell dredging would occur in all reaches upstream of and including the South reach. Use of clamshell dredges in these reaches would substantially reduce the number of Dungeness crabs and marine fish entrained and killed by project construction with an unmodified hopper dredge. Based on the work by Armstrong, et al. (1981) in assessing crab entrainment by dredges operating in Grays Harbor, approximately 2,750-57,000 crabs would be killed by project construction, which represents a .55-1.90 percent loss to the fishery in each year without mitigation. This estimate is about 40 percent less than the number of crabs which would probably be killed by project construction under the REC plan without mitigation.

Direct-dredging related impacts to smaller invertebrates in the sediments and juvenile salmonids will be similar to those associated with the REC plan.

Water quality impacts during dredging will be slightly less with the LED plan than the REC plan since clamshell dredges will be used more under the LED plan.

Under the LED plan, all dredged material suitable for open-water disposal will be discharged at one or more ocean disposal sites within 8 miles of the harbor mouth. These sites would be chosen to minimize biological and commercial fishing impacts in the ocean and minimize return of sediments to Grays Harbor. Therefore, secondary impacts to primary producers, invertebrates, and fish in Grays Harbor associated with dredged material disposal would be negligible.

Ocean impacts associated with the LED plan would increase over those expected under the REC plan because more material would be discharged into the ocean. However, this additional sediment will be mainly sandy material which will cause minimal impacts.

Under the LED plan, increased quantities of dredged material would be discharged into the ocean in order to avoid impacts to the estuarine environment. As a result, direct impacts to the water column would be increased and benthic changes within the discharge site would be more pronounced. The LED ocean disposal site(s) would also be located outside of high density pelagic and benthic fishery areas.

SECTION 5. PUBLIC INVOLVEMENT

5.01 Public Involvement Program. The public involvement concerning this project which occurred through 1976 is described in section 9 of the revised draft (RD) Widening and Deepening EIS, 1976. Recent newsletters which were mailed to interested agencies and individuals as well as public workshops which were convened to discuss this project are described in section 5 of the feasibility report.

a. Coordination with Governmental and Public Environmental Agencies. By letter of 15 June 1979, the Seattle District invited representatives from the U.S. Environmental Protection Agency (EPA); Fish and Wildlife Service (FWS); National Marine Fishery Service (NMFS); Washington State Department of Ecology (WDE); and Washington State Departments of Game (WDG), Fisheries (WDF), and Department of Natural Resources (DNR) to participate in a task force effort to define the scope and cost of environmental studies necessary to determine the impacts of the proposed navigation improvement project in Grays Harbor. Additionally, the Port of Grays Harbor (the local sponsor), Washington Environmental Council (WEC), Friends of the Earth (FOE), and the Institute for Marine Studies of the University of Washington were invited to participate in the scoping process.

The task force broadly examined a list of suggested environmental studies for Grays Harbor that had been compiled from various sources and with varying applicability to the channel improvement project. From the onset, the task force was reminded by Corps representatives that studies scoped must be project related and should concentrate on those areas and resources that may be affected by the project.

The task force identified three primary areas of concern: water quality, fisheries, and wetlands/wildlife, and established subcommittees to meet and develop specific study scopes on these areas which could be impacted by the project.

These study scopes were discussed at numerous task force subcommittee meetings and ultimately a reduced list of proposed studies (table EIS 4-1) was presented to the entire task force on 26-27 September 1979. The task force agreed that the results of the proposed studies would form the base from which the state, Federal, and public agencies could determine if the proposed project was environmentally acceptable. The enviromental studies were begun in September 1979 and the results of all these studies, except the bioassay tests, were distributed to agencies listed above by March 1982. Several meetings between agency representatives, Seattle District personnel, and environmental studies contractors were held during 1980 and 1981. These meetings were held to keep agency representatives aware of preliminary study findings and also to allow the representatives to give suggestions or comments to the contractors. Additionally, Seattle District personnel met numerous times with resource

agency personnel to discuss potential ocean disposal areas, bioassay techniques, and the approach to the results of the chemical testing of sediments from Grays Harbor. During the task force meetings and task force coordination, resource agencies have: (a) expressed acceptance of the least environmentally damaging (LED) plan, (b) expressed lack of support for the national economic development (NED) plan, and (c) indicated that the NED plan appears to result in unacceptable adverse impacts. Seattle District COE developed a recommended (REC) plan which addressed some of the concerns tha agencies had with the NED plan. This REC plan has been generally accepted by the resource agencies.

The task force representatives were also invited to a 1-2 December 1981 meeting at which the REC plan, results of the environmental studies, additional studies being considered for the continuation of planning and engineering (CP&E) phase of this project, and possible mitigation measures were discussed in detail. Comments received from task force members during and after this meeting were considered as all the items listed above were being finalized for inclusion in this feasibility report/EIS. Written comments on the REC plan requested at the meeting indicate that the agencies generally concur with the project as proposed, though a few specific concerns remain. Some of these concerns are addressed in the EIS. The biological testing will be completed as part of project feasibility, and the results will be distributed in June 1982 for review. Other concerns such as using additional clamshell to reduce crab mortality, the precise location of ocean disposal sites, and sediment recirculation related to in-harbor disposal will be evaluated during CP&E.

b. Fish and Wildlife Coordination Act Report. In accordance with the Fish and Wildlife Coordination Act (FWCA) of 1958 (Public Law 85-624), as amended, a final draft FWCA report on this project, dated May 1982, was prepared by the Olympia, Washington, field office of the FWS and provided to the Corps. The FWCA report is attached to this feasibility report/EIS as part of appendix B. The recommendations made by the FWS in the FWCA report are addressed below.

(1) Mitigation.

o We agree that the loss of 4 acres of shallow subtidal habitat in the inner estuary should be replaced because of its limited availability and its importance to juvenile salmonids in inner Grays Harbor. Accordingly, our report recommends acquisition of appropriate mitigation lands.

o We will attempt to reduce Dungeness crab entrainment through dredge modification. If dredge modification is not a feasible way to reduce the number of crabs entrained, the following would be considered: (a) increasing survival of crabs (especially juveniles) already present in the harbor through altering and improving presently available habitat and/or (b) developing means to increase the natural survival of crabs in Grays Harbor. The actual amount of mitigation for

crab losses necessary depends upon the significance of the loss to the Grays Harbor population. This significance will be refined through CP&E phase studies.

(2) Continuation of Planning and Engineering Studies.

o We will continue yearly surveys to determine scouring rates at the inner harbor disposal sites. These yearly surveys, which go back to the early 1900's, are the basis for the erosion predictions we are presently using (along with the known volume of material deposited from our dredging records). Determining these changes for various times of the year would require additional surveys which are very expensive. The primary scouring forces are the tidal currents which do not significantly change by season, and we do not foresee major seasonal scour rate changes at the estuary mouth. We will sample sediments during CP&E and anticipate that these tests would attempt to determine the direction and magnitude of silt movement from the disposal area. Hopefully, the sampling can coincide with a future maintenance dredging contract. We do not believe that consolidation tests are warranted; sands disposed at the site would consolidate shortly after dumping, while we expect silts to remain relatively unconsolidated up to the time they are eroded by tidal currents.

o We agree that the modification of dredging equipment may reduce the number of Dungeness crabs which are entrained by the dredges. We will evaluate the potential of various types of modifications for reducing entrainment during the CP&E studies.

o We are considering additional studies on crab distribution and abundance within Grays Harbor during CP&E and will refine our proposed dredging schedule if these studies indicate that such refinement would substantially reduce impacts to Dungeness crabs.

o CP&E studies will be conducted to designate an acceptable ocean disposal site or sites. Some studies are discussed in the project EIS and appendix A which discusses ocean disposal site selection.

Refer to paragraph 4.33 of the feasibility report for a list of special CP&E studies.

(3) Enhancement. The enhancement opportunities proposed by the U.S. Fish and Wildlife Service cannot be recommended by Seattle District because there is no local sponsor for any of the enhancement measures. In addition, perching sites and stream enhancement measures are physically outside the project area and would enhance fish and wildlife habitats which are unrelated to project impacts. However, the second enhancement recommendation in the Fish and Wildlife Cordination Act report which includes acquisition of the treatment of land in excess of that previously proposed in the REC plan will be evaluated during CP&E.

We will insure that temporary project construction and maintenance impacts on water quality are kept at an acceptable level by dredging in accordance with the Department of Ecology Water Quality Guidelines for dredging in inner Grays Harbor and lower Chehalis River.

5.02 Remaining Coordination. The bioassay tests will be completed in June during the public review process of this document. The results of those tests which have been completed are included in appendix A, exhibit 2, of the EIS. Upon completion of the tests, a supplemental information package with the results will be distributed to all recipients of this document. Should the project be authorized, further coordination with resource agencies and interested public will take place during CP&E studies, preparation of plans and specifications, and construction.

5.03 Statement Recipients. The draft feasibility report, EIS, and appendixes will be distributed to the public for a 45-day review period. Comments on the draft EIS will be responded to in a final EIS and revisions will be incorporated into the final feasibility report where appropriate. A list of persons, groups, and agencies who receive the report will be presented in appendix B.

5.04 Public Views and Responses. To be completed after public review of the draft feasibility report/EIS.

LIST OF PREPARERS
The following people were primarily responsible
for preparing this EIS

Name	Discipline/ Expertise	Experience	Role in Preparing EIS
Principal Authors			
Peggy Watt, B.S.	Biologist/ Environmental Planning	Biologist, Corps of Engineers, 1 yr; Educational Programs, Coordination Assistant, Seattle Aquarium, 1 yr; Biologist, Marine World, California, 1 yr.	EIS coordination; Effects on Environmental Resources; 404(b)(1) Evaluation; Agency Coordination
John Armstrong, PhD.	Fisheries Biologist/ Environmental Planning	Environmental Planner/Coordinator, Corps of Engineers, 5 yrs; Fisheries Biologist, Univ. of Wash, 5 yrs; Fisheries Biologist, Michigan State University, 2 yrs.	Environmental Coordinator; Public & Agency Coordination; Formulation of Alternatives; Needs Assessment, Mitigation
Ron Thom, PhD.	Biologist/Marine & Estuarine Ecology	Biologist, Corps of Engineers, 2 yrs; Marine Biologist, Univ of Wash, 6 yrs; Biologist, Los Angeles County 3 yrs.	Effects on Estuarine Ecology; Effects on Crab Resource; edit EIS.
Keith Phillips, B.S.	Biological Oceanography/Marine Ecology	Oceanographer, Corps of Engineers, 4 yrs.	Effects of Ocean Disposal; Section 103 Evaluation and Biological Testing of Dredged Material.
Contributing			
Ken Brunner	Wildlife Biologist	Wildlife Biologist, Corps of Engineers, 6 yrs.	Effects on Wildlife Resources; Threatened & Endangered Species Biological Assessment
Fred Weinmann, PhD.	Program Manager/ Estuarine Ecologist	Environmental Resources Section, Seattle District Corps of Engineers 8 yrs; Marine Biologist, State of Washington, 1 yr; Research Associates, University of Washington, Department of Civil Engineering, 3 yrs.	EIS overview
Frank Urabeck, M.A.	Water Resources Management	Chief, Navigation & Coastal Planning Section, Corps of Engineers, 3 yrs; Director, South Central Alaska Water Resources Study U.S. Bureau of Land Management, 2 yrs; Study Manager, Water Resources Planning, Corps of Engineers, 7 yrs. Civil Engineer, Comprehensive & Environmental Planning, Corps of Engineers, 5 yrs.	Study Manager; Impact Assessment; Public and Agency Coordination
A. David Schuldt, P.E.	Coastal Engineer	Navigation & Coastal Planning, Corps of Engineers, 12 yrs; U.S. Coast	Hydraulics; Sedimentation; Design & Cost Analysis
Mark Ohlstrom, M.B.A.	Water Resources Management	Assistant Study/ Coastal Engineer, Corps of Engineers, 3 yrs.	Study Coordination; Technical Review

GRAYS HARBOR EIS BIBLIOGRAPHY

Akins, G. J. and C. A. Jefferson, 1973. Coastal Wetlands of Oregon: A Natural Resources Inventory Report to the Oregon Coastal Conservation and Development Commission, 159 pp.

Albright, R. and P. K. Bouthillette, 1982. Benthic Invertebrate Studies in Grays Harbor, Washington. Washington Department of Game, Prepared for Seattle District, U.S. Army Corps of Engineers, Seattle Washington, ___ pp.

AM Test, Incorporated, 1981. Chemical Testing of Sediments in Grays Harbor, Washington. Grays Harbor and Chehalis River Improvements to Navigation Environmental Studies. Prepared for Seattle District, U.S. Army Corps of Engineers, Seattle, Washington, 112 pp.

Armstrong, D. A., B. . Stevens, and J. C. Hoeman, 1981. Distribution and Abundance of Dungeness Crab and Crangon Shrimp and Dredging-Related Mortality of Invertebrates and Fish in Grays Harbor, Washington, pp. 349 and Appden.

Bengston, C. and J. Brown, 1976. Appendix G, Impact of Dredging on the Fishes of Grays Harbor. Maintenance Dredging and the Environment of Grays Harbor, Washington. U.S. Army Corps of Engineers, Seattle District, Seattle, Washington, 125 pp.

Brunner, K. R., 1981. Grays Harbor and Chehalis and Hoquiam Rivers Improvements to Navigation Study Biological Assessment on Federally Listed Endangered Marine Animals. On file at U.S. Army Corps of Engineers, Seattle District, Seattle, Washington, 9 pp. (unpublished).

Brunner, K. R., 1982. Grays Harbor and Chehalis and Hoquiam Rivers Improvements to Navigation Study Biological Assessment on Federally Listed Endangered Brown Pelican. On file at U.S. Army Corps of Engineers, Seattle District, Seattle, Washington (unpublished).

Brunner, K. R., 1981. Grays Harbor and Chehalis and Hoquiam Rivers Improvements to Navigation Study Biological Assessment on Federally Listed Endangered Peregrine Falcon and Bald Eagle. On file at U.S. Army Corps of Engineers, Seattle District, Seattle, Washington (unpublished).

Cordell, J. R. and C. A. Simenstad, 1981. Community Structure and Standing Stock of Epibenthic Zooplankton at Five Sites in Grays Harbor, Washington. University of Washington, Fisheries Research Institute, Seattle, Washington, Prepared for Seattle District, U.S. Army Corps of Engineers, 28 pp.

Department of Ecology, 1981. Washington State Air Monitoring Data.

Durkin, J. T. and S. J. Lipovsky, 1977. Appendix E, Demersal Fish and Decapod Studies. Aquatic Disposal Field Investigations, Columbia River Disposal Site, Oregon. Dredged Material Research Program, Technical Report D-77-30, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi.

Duxbury, A. C., 1979. Upwelling and Estuary Flushing. Limnology and Oceanography, Volume 24, No. 4, pp. 627-633.

Eaton, R. L. (editor), 1975. Marine Shoreline Fauna of Washington, A Status Survey. Coastal Zone Environmental Studies Report No. 2. Washington Deparment of Game and Washington Department of Ecology, Olympia, Washington, 594 pp.

Ericksen, A. and L. D. Townsend, 1940. The Occurrence and Cause of Pollution in Grays Harbor, Washington, Olympia, Washington. Washington State Pollution Control Commission, Bulletin No. 2, 100 pp.

Federal Register, 28 November 1980. Volume 45, No. 231. Environmental Protection Agency, Water Quality Document Availability pp. 79318-79379.

Federal Register, 1981. 40 CFR 50, National Ambient Air Quality Standard.

Federal Register, 1978. No. 238, pp. 6230-6233.

Glancy, P. A., 1971. Sediment Transport by Streams in the Chehalis River Basin, Washington, October 1961 to September 1965, Tacoma, Washington. U.S. Geological Survey, Water-Supply Paper 1798-H, 53 pp.

Herman, S. G., 1980. Personal Communication with Ken Brunner, U.S. Army Corps of Engineers. Evergreen State College, Olympia, Washington.

Herman, S. G. and J. B. Bulger, 1981. The Distribution and Abundance of Shorebirds During the 1981 Spring Migration at Grays Harbor, Washington. Prepared for Seattle District, U.S. Army Corps of Engineers, 64 pp.

Isakson, J. S. and T. A. Reichard, 1976. Critical Study Area Study. Department of Ecology Baseline Studies, Mathematical Science Northwest and Washington Department of Ecology. Bellevue, Washington 5 pp.

Juhnke, L., 1981. Dredge Equipment and Schedule Modification to Minimize Adverse Impact on Fisheries. On file at U.S. Army Corps of Engineers, Seattle District, Seattle, Washington, 7 pp. (unpublished).

Kehoe, D. M., 1982. Sources of Sediment to Grays Harbor Estuary. U.S. Army Corps of Engineers, Seattle District, Seattle, Washington (in preparation).

Larrison, E. J., 1976. Mammals of the Northwest, Washington, Oregon, Idaho, and British Columbia. Seattle Audubon Society, Washington, 256 pp.

Lewin, J., 1978. Blooms of Surf Diatoms Along the Coast of the Olympic Peninsula, Washington, i.x. Factors Controlling the Seasonal Cycle of Nitrate in the Surf at Copalis Beach, (1971 through 1975) Estuarine and Coastal Marine Science, Volume 7:1978, pp. 173-183.

Lindsay, C., H. Tegelberg, and R. Arthur, 1976. Distribution of Dungeness Crabs (Cancer magister) in Grays Harbor, and Same Effects of Channel Maintenance Dredging. In Maintenance Dredging and the Environment of Grays Harbor, Washington. U.S. Army Corps of Engineers, Seattle District, Seattle, Washington, 94 pp.

Loehr, Lincoln C., and E. Collias, 1981. A Review of Water Characteristics of Grays Harbor, 1938-1979, and an Evaluation of Possible Effects of the Widening and Deepening Project Upon Present Water Characteristics. University of Washington, Department of Oceanography, Seattle, Washington, Prepared for Seattle District, U.S. Army Corps of Engineers, 97 pp.

Maas, Jonathan, 1980. Grays Harbor Sediment Cores-Cutural Resources Study. On file at U.S. Army Corps of Engineers, Seattle District, Seattle, Washington (unpublished).

Mate, B. R., 1979. Gray Whales, Eschrichtius robustus. Learning About the Oceans. Oregon Sate University Extension Service Publication, 2 pp.

McCauley, J. E., 1977. Benthic Infauna and Maintenance Dredging: A Case Study. Water Research 11(2), pp. 233-242.

Miller, G. H., 1977. Eelgrass Distribution, Density, Leaf Length, and Standing Stock in Grays Harbor, Washington. Washington Department of Game, Prepared for Seattle District, U.S. Army Corps of Engineers, 22 pp.

National Marine Fisheries Service, 1975. Marine Mammals Division, Department of Commerce, Northwest Fisheries Center, Seattle, Washington.

Nelson, W. H., S. Kalinowski, and L. Lynam, 1980. Chehalis River Floodplain Land Cover Mapping Between Aberdeen and Montesano, Washington. Washington Department of Game, Prepared for Seattle District, U.S. Army Corps of Engineers, 45 pp.

Norman Associates (consulting engineers), 1974. Offshore Petroleum Transfer Systems for Washington State, A Report to the 44th Legislature, State of Washington.

Phillips, R. C., 1974. Temperate Grass Flats. In H. T. Odum, et al., Coastal Ecological Systems of the United States, Volume II, the Conservation Foundation, Washington D.C., pp. 244-299.

Phipps, J. B., B. Gage, and J. Caryl, 1976. Grain Size Analysis of Some Grays Harbor Estuary Sediment Samples. In Maintenance Dredging and the Environment of Grays Harbor, Washington. U.S. Army Corps of Engineers, Seattle District, Seattle, Washington, 8 pp. and Appden.

Pinson, R. B., L. D. Tornberg, J. W. Nichols, and R. E. Nakatani, 1981. A Bioassay Protocol for Evaluation of Potential Chemical Toxicity From Disposal of Dredged Sediments. University of Washington, Fisheries Research Institute, Seattle, Washington, Prepared for Seattle District, U.S. Army Corps of Engineers, Seattle, Washington, 140 pp. (unpublished).

Pike, C. G. and I. B. MacAskie, 1969. Marine Mammals of British Columbia. Fisheries Research Board of Canada, Bulletin 171, 54 pp.

Rice, D W. and A. A. Wolman, 1971. The Life History and Ecology of the Gray Whale, Eschrichtius robusta. Special Publication No. 3, American Society of ammalogists, Stillwater, Oklahoma, 142 pp.

Schuldt, D., 1981. Sea Bottom and Surface Drifter Studies of the Entrance, Bar and Offshore Area of Grays Harbor. In Grays Harbor Widening and Deepening Feasibility Study Technical Support Report, Section 4. On File at U.S. Army Corps of Engineers, Seattle District, Seattle, Washington.

Simenstad, C. A. and D. M. Eggers, 1981. Juvenile Salmonid and Baitfish Distribution, Abundance and Prey Resources in Selected Areas of Grays Harbor, Washington. University of Washington, Fisheries Research Institute, Seattle, Washington, Prepared for Seattle District U.S. Army Corps of Engineers, 205 pp.

Smith, J. L., R. Albright, and A. D. Rammer, 1976. Appendix E, The Effect of Intertidal Dredged Material Disposal on Benthic Invertebrates in Grays Harbor, Washington. Maintenance Dredging and the Environment of Grays Harbor, Washington. U.S. Army Corps of Engineers, Seattle District, Seattle, Washington, 224 pp.

Smith, J. L., D. R. Mudd, and L. M. Messmer, 1976. Appendix F, Impact of Dredging on the Vegetation in Grays Harbor. Maintenance Dredging and the Environment of Grays Harbor, Washington. U.S. Army Corps of Engineers, Seattle District, Seattle, Washington, 121 pp.

Smith, J. L. and D. R. Mudd, 1976. Appendix H, Impact of Dredging on the Avian Fauna in Grays Harbor. Maintenance Dredging and the Environment of Grays Harbor, Washington. U.S. Army Corps of Engineers, Seattle District, Seattle, Washington, 217 pp.

Smith, J. L. and D. R. Mudd, 1976. Appendix I, Impacts of Dredging on the Mammalian Fauna in Grays Harbor. Maintenance Dredging and the Environment of Grays Harbor, Washington. U.S. Army Corps of Engineers, Seattle District, Seattle, Washington, 47 pp.

Smith, J. M., J. B. Phipps, E. D. Schermer, and D. F. Samuelson, 1975. Appendix K, Impact of Dredging on the Water Quality in Grays Harbor. Maintenance Dredging and the Environment of Grays Harbor, Washington. U.S. Army Corps of Engineers, Seattle District, Seattle, Washington, 221 pp.

Smith, J. M., L. W Messner, J. B. Phipps, D. F. Samuelson, and E. D. Schermer, 1980. Grays Harbor Ocean Disposal Study: Literature Review and Preliminary Benthic Sampling. Grays Harbor College, Aberdeen, Washington, Prepared for Seattle District, U.S. Army Corps of Engineers, 160 pp.

Stevens, B. G., 1981. Dredging-Related Mortality of Dungeness Crabs Associated with Four Dredges Operating in Grays Harbor, Washington. Washington Department of Fisheries, Prepared for Seattle District, U.S. Army Corps of Engineers, 148 pp.

Storm, P. C., 1981. A Literature Review of the Bacterium Klebsiella spp. U.S. Army Corps of Engineers, Seattle District, Seattle, Washington, 21 pp.

Thom, R. M., 1981. Primary Productivity and Carbon Input to Grays Harbor Estuary, Washington. U.S. Army Corps of Engineers, Seattle District, Seattle, Washington, 71 pp.

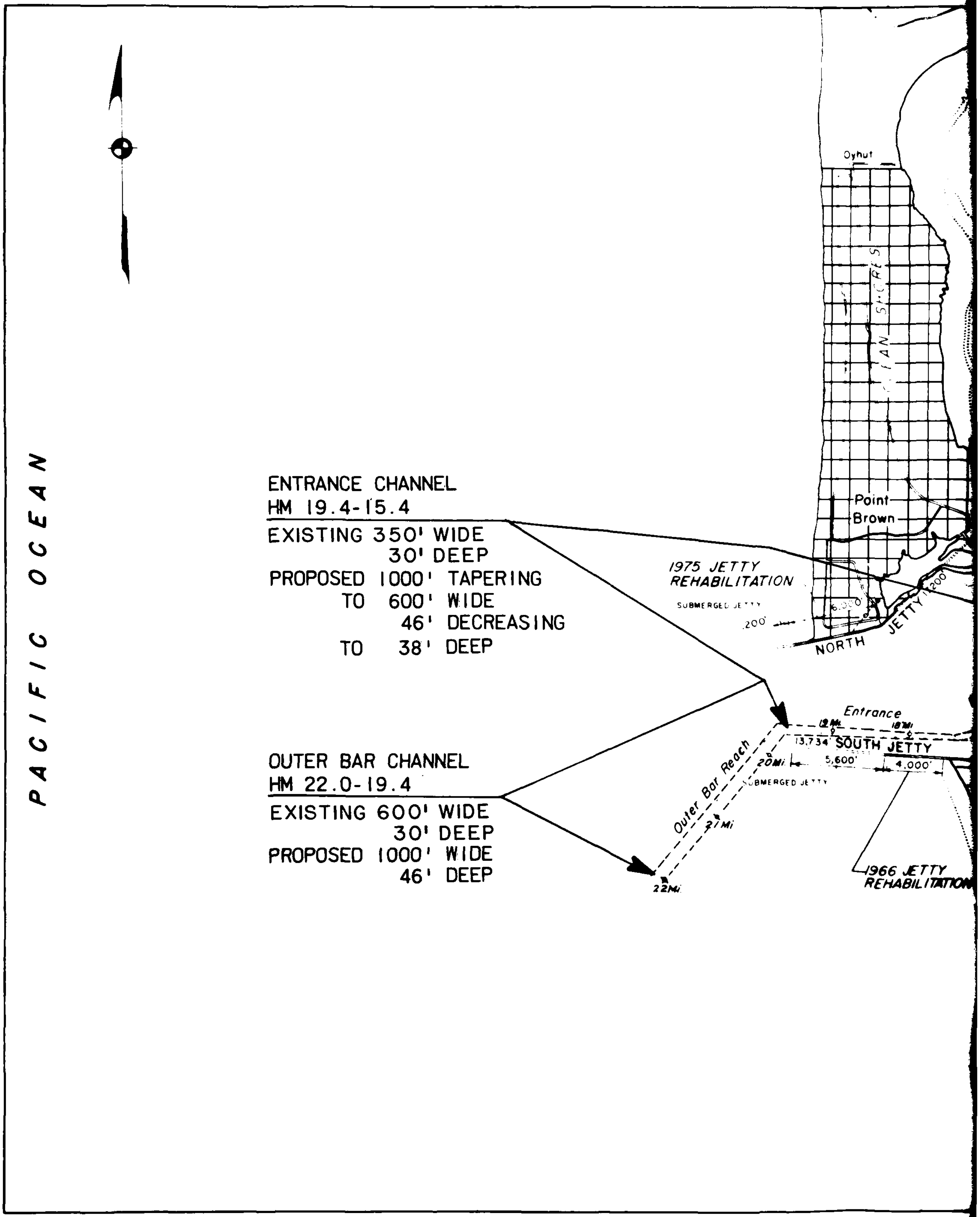
U.S. Army Corps of Engineers, Seattle District, 1976. Grays Harbor Widening and Deepening EIS (revised), 229 pp.

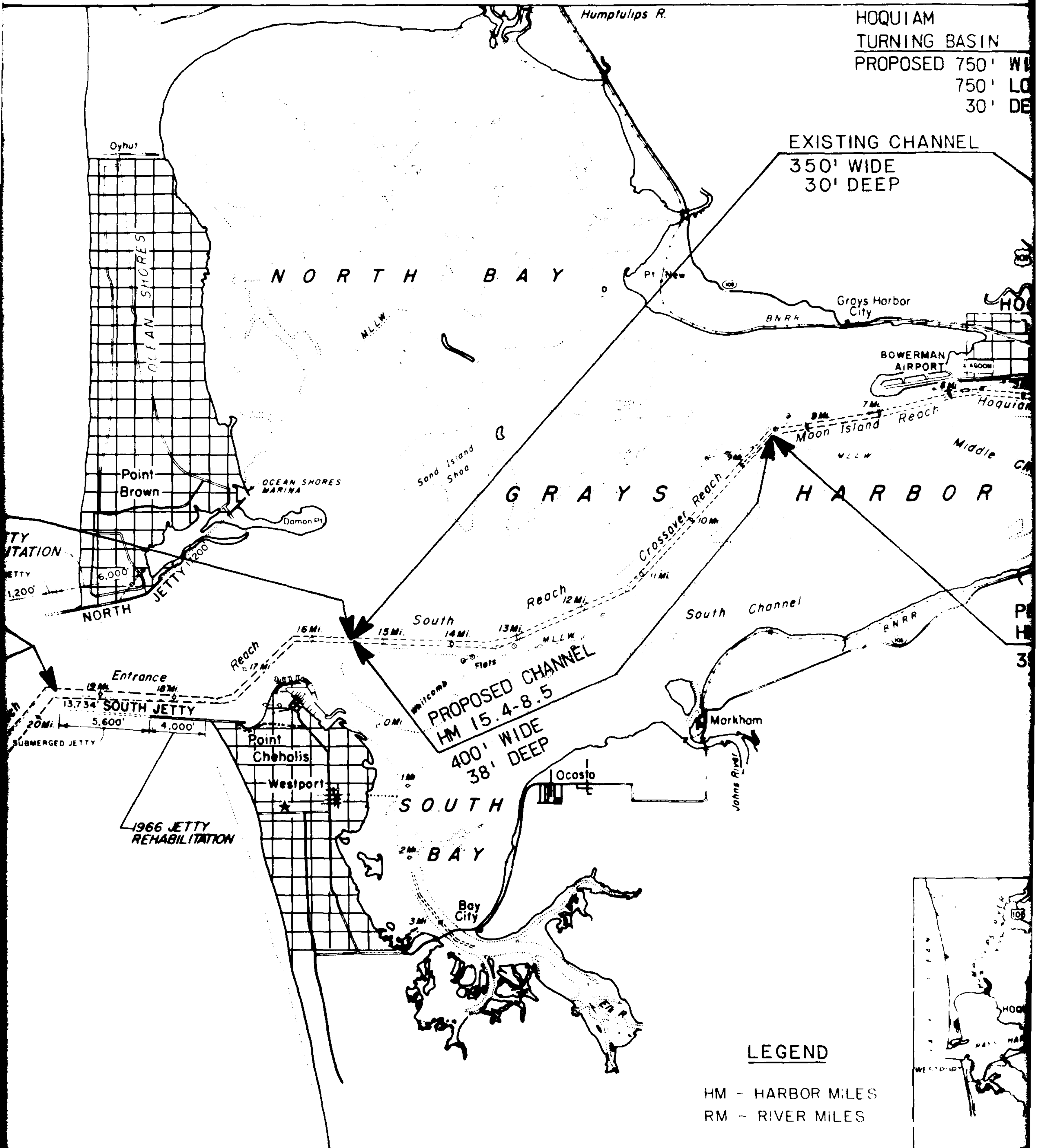
U.S. Army Corps of Engineers, 1980. Long-Range Maintenance Dredging Program. Grays Harbor and Chehalis River Navigation Project, Operation and Maintenance. Seattle, Washington, 82 pp. and Append.

U.S. Department of Commerce, Bureau of Census, 1981. 1980 Census of Population and Housing.

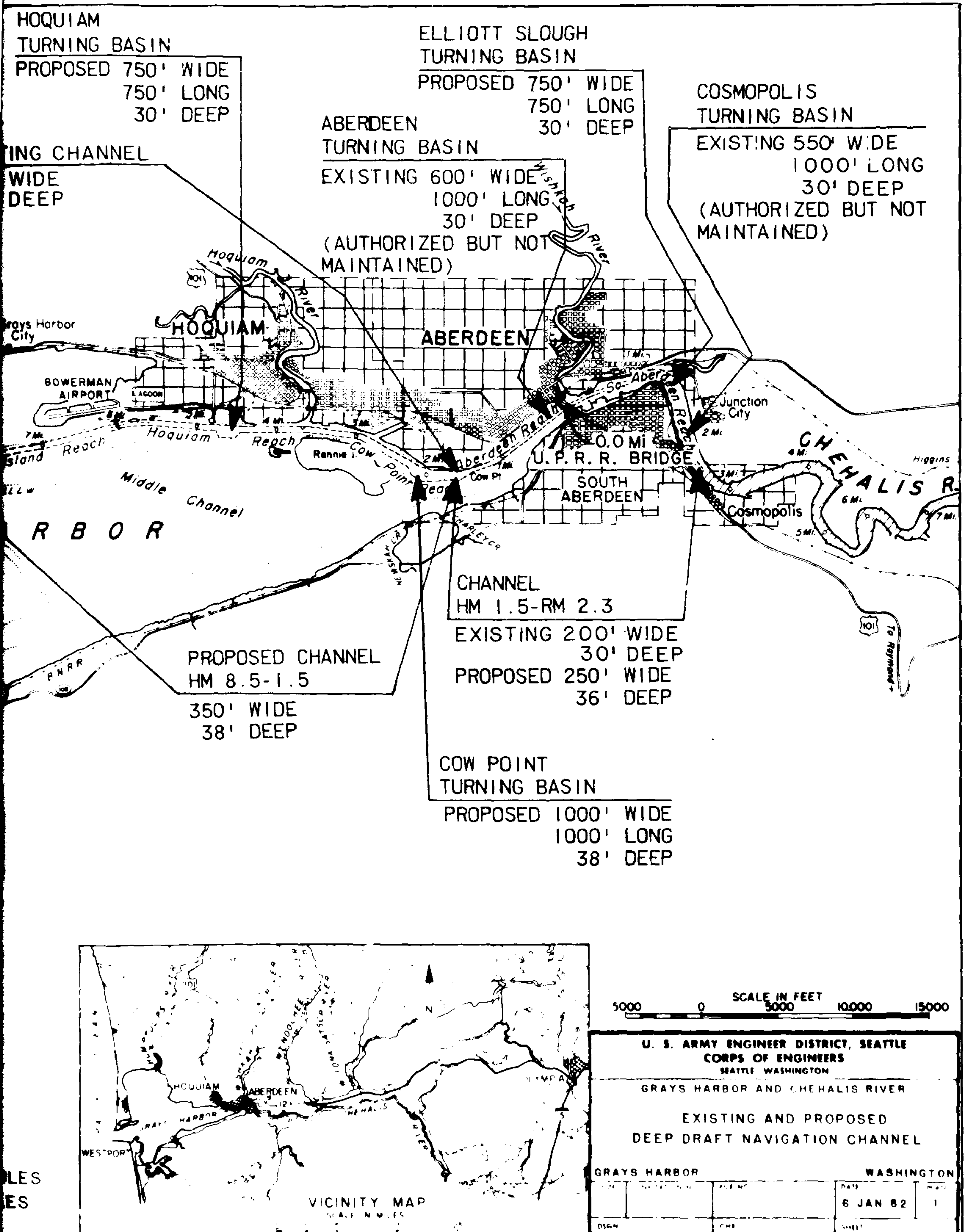
U.S. Environmental Protection Agency, 1976. Quality Criteria for Water: USEPA, Washington, D.C.

PLATES


PACIFIC OCEAN
ENTRANCE CHANNEL
HM 19.4-15.4
EXISTING 350' WIDE
30' DEEP
PROPOSED 1000' TAPERING
TO 600' WIDE
46' DECREASING
TO 38' DEEP
OUTER BAR CHANNEL
HM 22.0-19.4
EXISTING 600' WIDE
30' DEEP
PROPOSED 1000' WIDE
46' DEEP
Oyhut
Point
Brown
1975 JETTY
REHABILITATION
SUBMERGED JETTY
200'
NORTH JETTY
Entrance
SOUTH JETTY
13,734
5,600'
4,000'
SUBMERGED JETTY
Outer Bar Reach
20 Mi
21 Mi
22 Mi
1966 JETTY
REHABILITATION



HOQUIAM
TURNING BASIN
PROPOSED 750' WI
750' LO
30' DE
EXISTING CHANNEL
350' WIDE
30' DEEP
Humptulips R.
Oyhut
OCEAN SHORES
NORTH BAY
M.L.L.W.
Pt New
Grays Harbor City
B.N.R.R.
BOWERMAN AIRPORT
LAGOON
Hoquiam
Moon Island Reach
Middle
Sand Island Shoal
Point Brown
OCEAN SHORES MARINA
Damon Pt
GRAYS HARBOR
Crossover Reach
10 Mi.
11 Mi.
NORTH JETTY
1,200'
6,000'
South Reach
12 Mi.
13 Mi.
14 Mi.
15 Mi.
16 Mi.
17 Mi.
18 Mi.
19 Mi.
20 Mi.
South Channel
Flats
Entrance Reach
13,734' SOUTH JETTY
5,600'
4,000'
SUBMERGED JETTY
PROPOSED CHANNEL
HM 15.4-8.5
400' WIDE
38' DEEP
Point Chehalis
Westport
Markham
Ocosta
Johns River
1966 JETTY REHABILITATION
SOUTH BAY
1 Mi.
2 Mi.
3 Mi.
Bay City
LEGEND
HM - HARBOR MILES
RM - RIVER MILES
WESTPORT

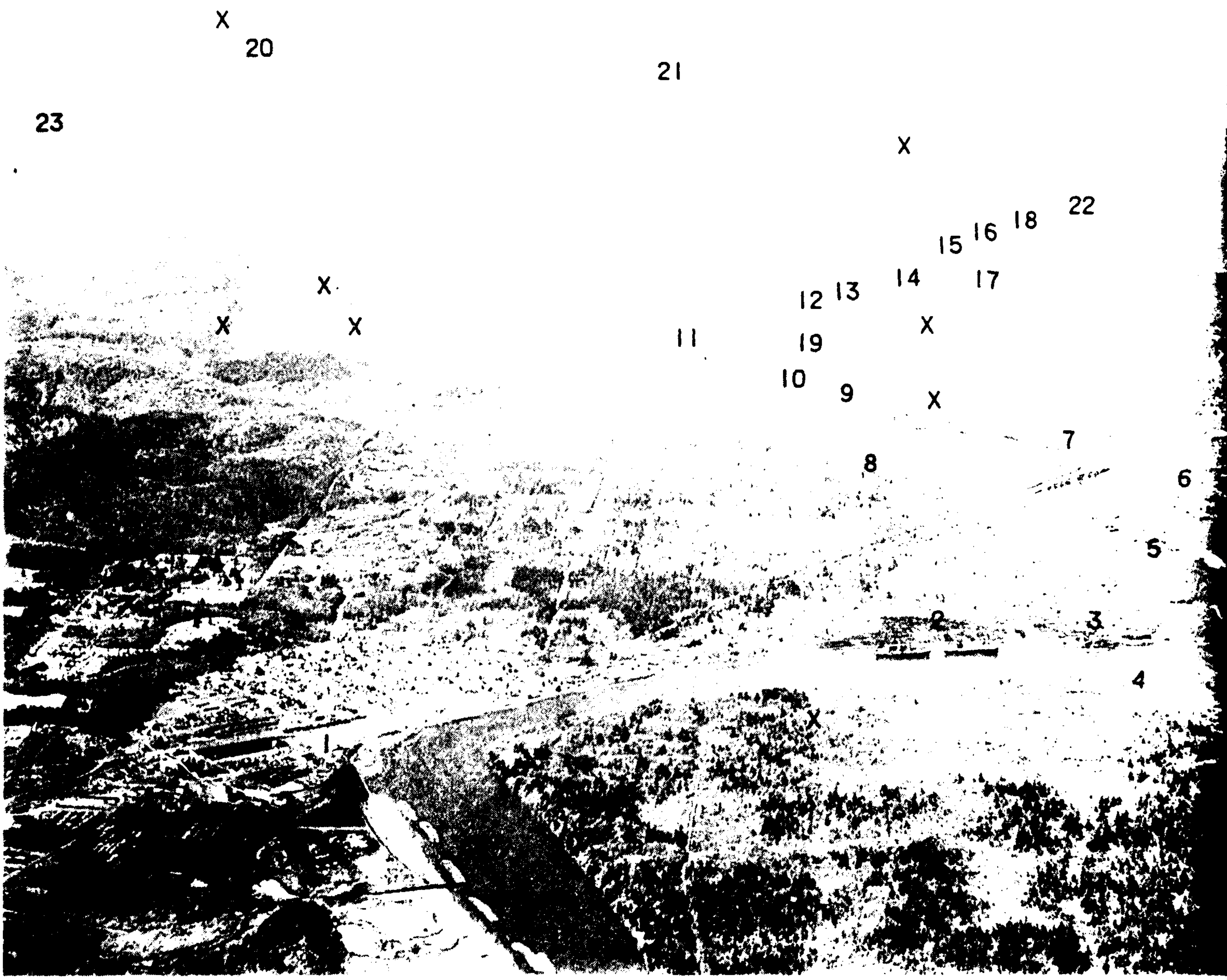

HOQUIAM
TURNING BASIN
PROPOSED 750' WIDE
750' LONG
30' DEEP
ELLIOTT SLOUGH
TURNING BASIN
PROPOSED 750' WIDE
750' LONG
30' DEEP
ABERDEEN
TURNING BASIN
EXISTING 600' WIDE
1000' LONG
30' DEEP
(AUTHORIZED BUT NOT
MAINTAINED)
COSMOPOLIS
TURNING BASIN
EXISTING 550' WIDE
1000' LONG
30' DEEP
(AUTHORIZED BUT NOT
MAINTAINED)
ING CHANNEL
WIDE
DEEP
Hoquiam River
Wishkah River
HOQUIAM
ABERDEEN
Grays Harbor City
BOWERMAN AIRPORT
LAGOON
Hoquiam Reach
Island Reach
Middle Channel
Rennie I.
Cow Point Reach
Cow Pt
Aberdeen Reach
So. Aberdeen Reach
0.0 Mi
U.P.R.R. BRIDGE
SOUTH ABERDEEN
Junction City
CHEHALIS R.
Higgins
Cosmopolis
RBOR
NEWSKAH CR.
HARLEY CR.
BNRR
To Raymond
CHANNEL
HM 1.5-RM 2.3
EXISTING 200' WIDE
30' DEEP
PROPOSED 250' WIDE
36' DEEP
PROPOSED CHANNEL
HM 8.5-1.5
350' WIDE
38' DEEP
COW POINT
TURNING BASIN
PROPOSED 1000' WIDE
1000' LONG
38' DEEP
HOQUIAM
ABERDEEN
GRAYS HARBOR
CHEHALIS
WESTPORT
N
VICINITY MAP
SCALE IN MILES
LES
ES
SCALE IN FEET
5000 0 5000 10,000 15000
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE WASHINGTON
GRAYS HARBOR AND CHEHALIS RIVER
EXISTING AND PROPOSED
DEEP DRAFT NAVIGATION CHANNEL
GRAYS HARBOR
WASHINGTON
DATE
6 JAN 82
1
DSGN
CHK
SHEET

INDUSTRIES ON GRAYS HARBOR AND CHEHALIS RIVER ESTUARY

1 WEYERHAEUSER CO. - Pulp
2 WEYERHAEUSER CO. - Log Terminal
3 E.C. MILLER - Cedar Lumber
4 PHILROD - Log Terminal
5 WEYERHAEUSER CO. - Lumber, Wood Chips Terminal
6 P.G.H. - I.D.D. NO. 2 - Commercial/Industrial Site
7 ANDERSON & MIDDLETON - Commercial/Industrial Site
8 SAGINAW SHINGLE MILL
9 QUIGG BROS. - McDONALD - Sand and Gravel
10 BOISE CASCADE - Logs/Lumber 23
11 P.G.H. TERMINAL 4 - Logs/Lumber
12 P.G.H. TERMINAL 2
13 P.G.H. TERMINAL 1 - Liquid Bulk
14 I.T.T. RAYONIER - GRAYS HARBOR PAPER - Pulp/Paper
15 P.G.H. - I.D.D. NO. 1 - Industrial Site
16 ANDERSON & MIDDLETON - Logs
17 GRAYS HARBOR DOCK CO. - Log/Lumber Terminal
18 I.T.T. RAYONIER WOOD PRODUCTS COMPLEX - Logs/Lumber
19 P.G.H. INDUSTRIAL AREA
20 WESTPORT MARINA - South Jetty
21 OCEAN SHORES MARINA - North Jetty
22 LAMB GRAYS HARBOR CO. - Machinery
23 OCEAN SPRAY CRANBERRIES
X MAJOR INDUSTRIAL SITES

PORT OF GRAYS HARBOR
ABERDEEN - HOQUIAM
MARCH 1982

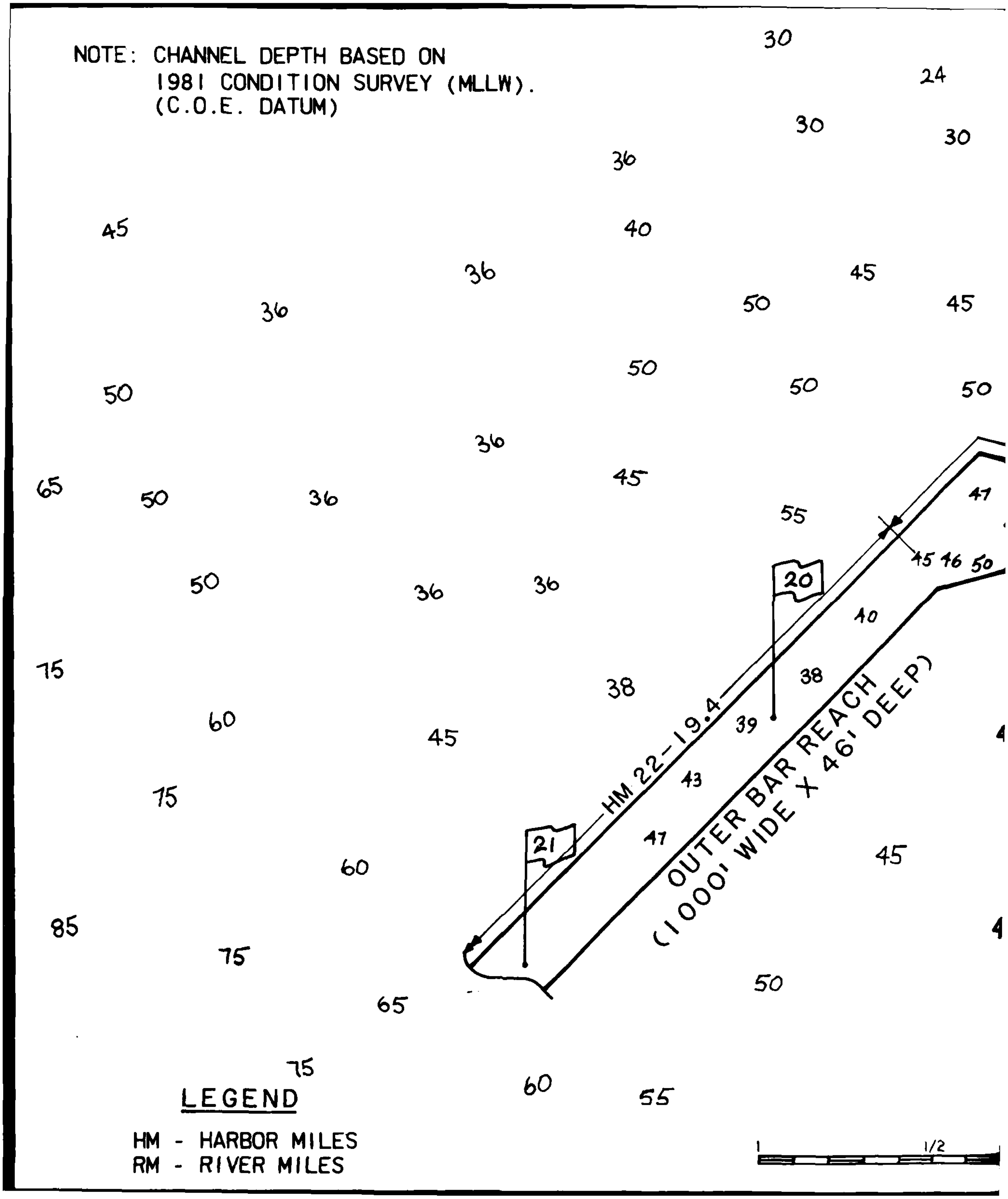
Site
lite

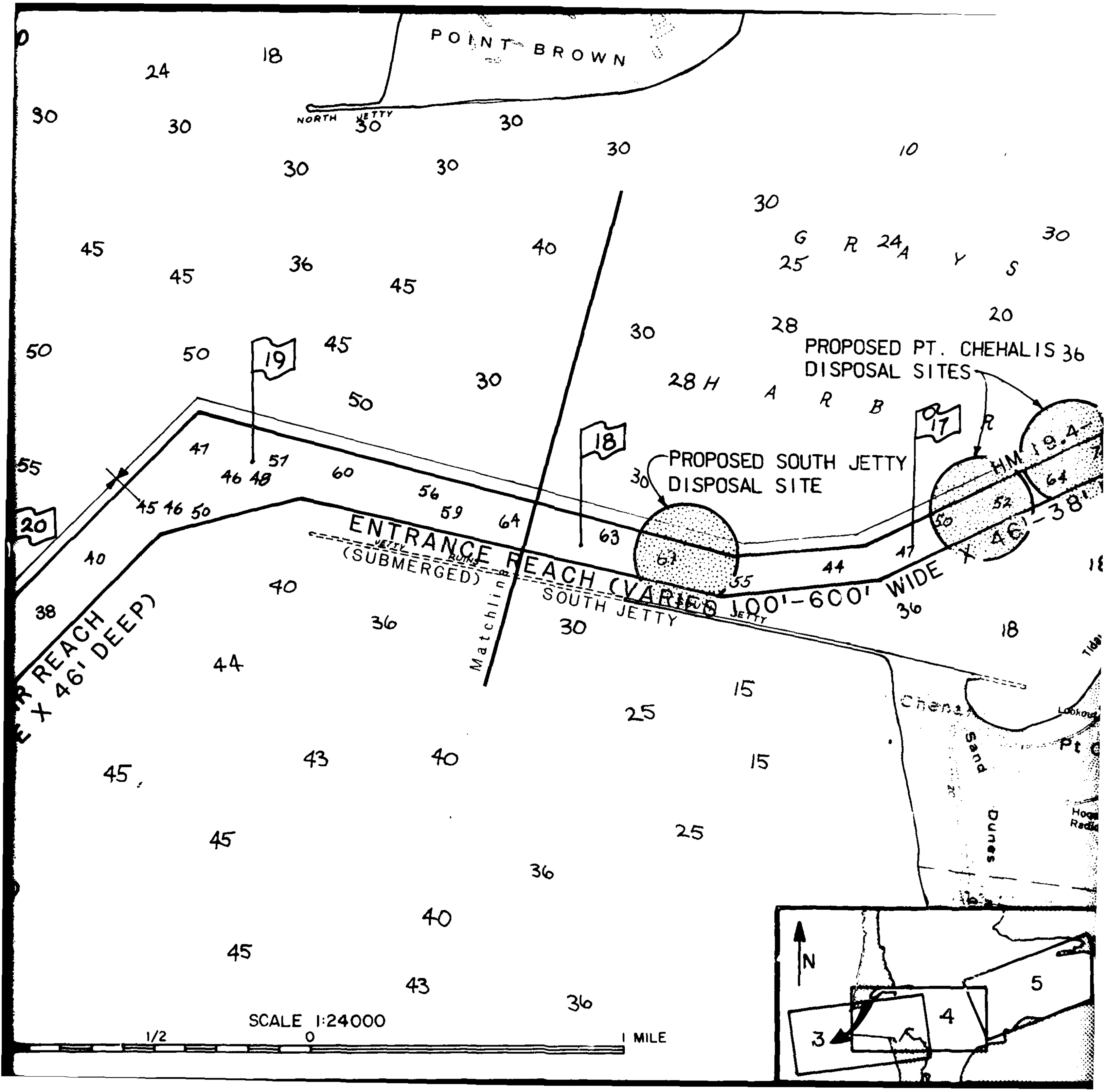


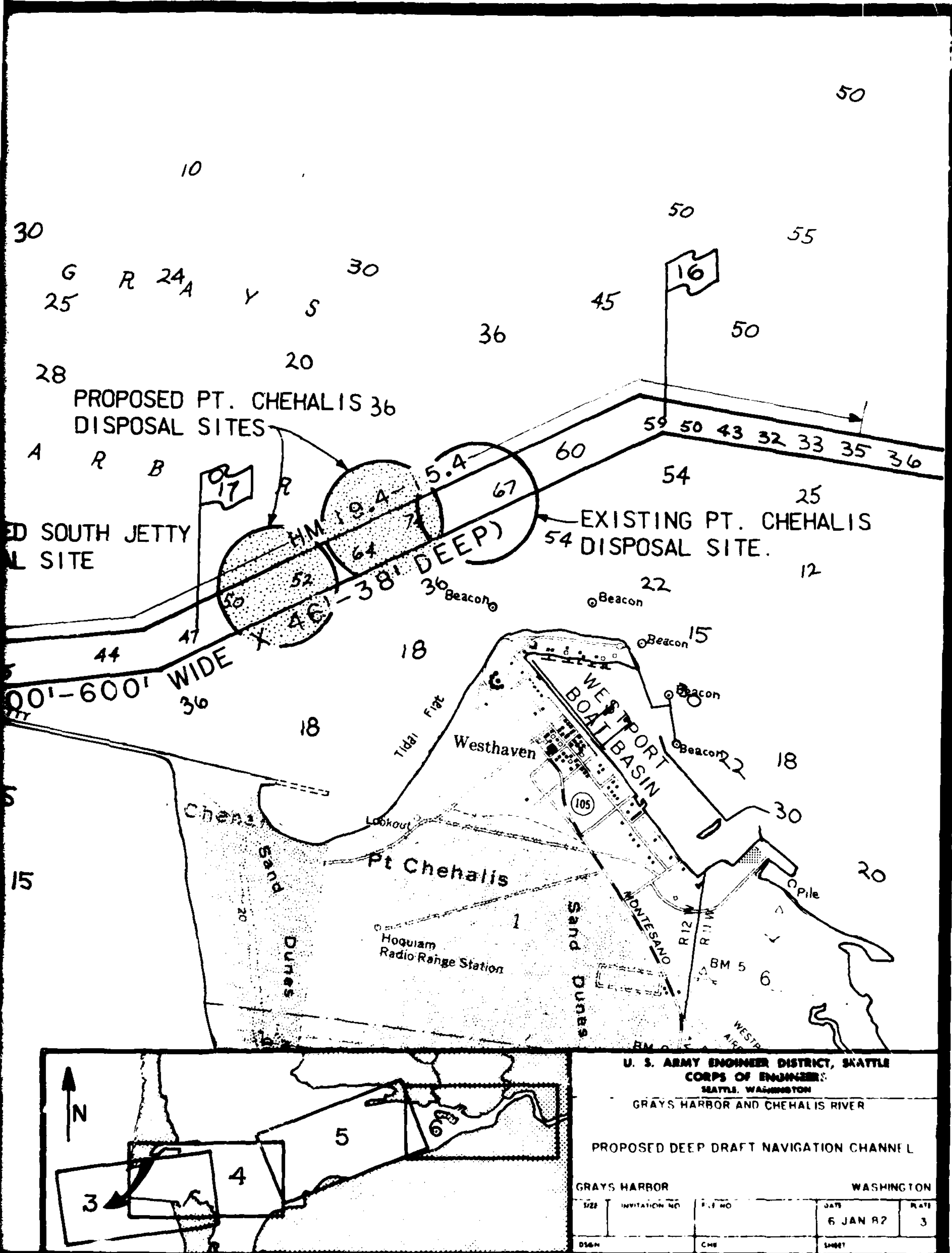
per

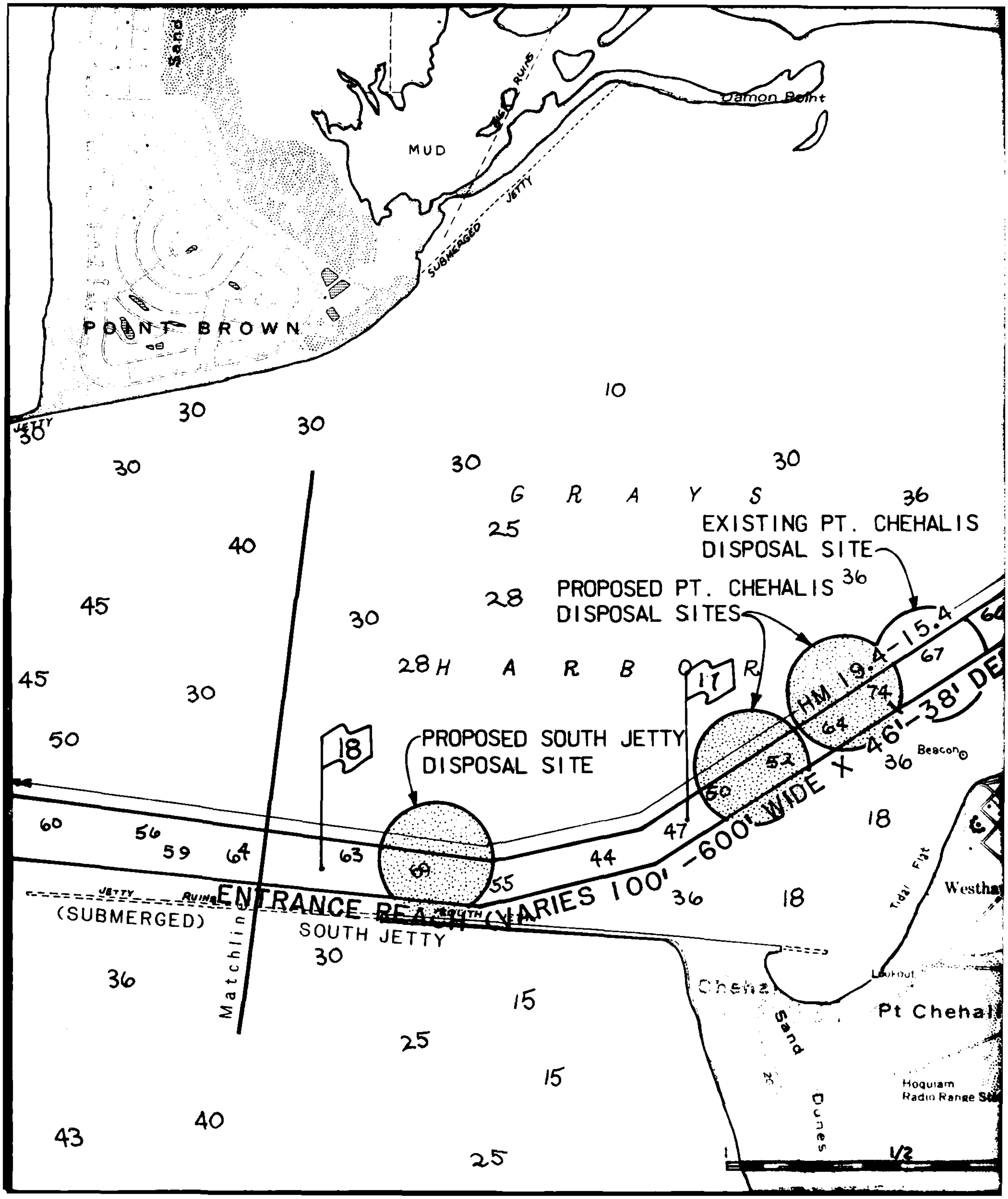
umber

PLATE 2

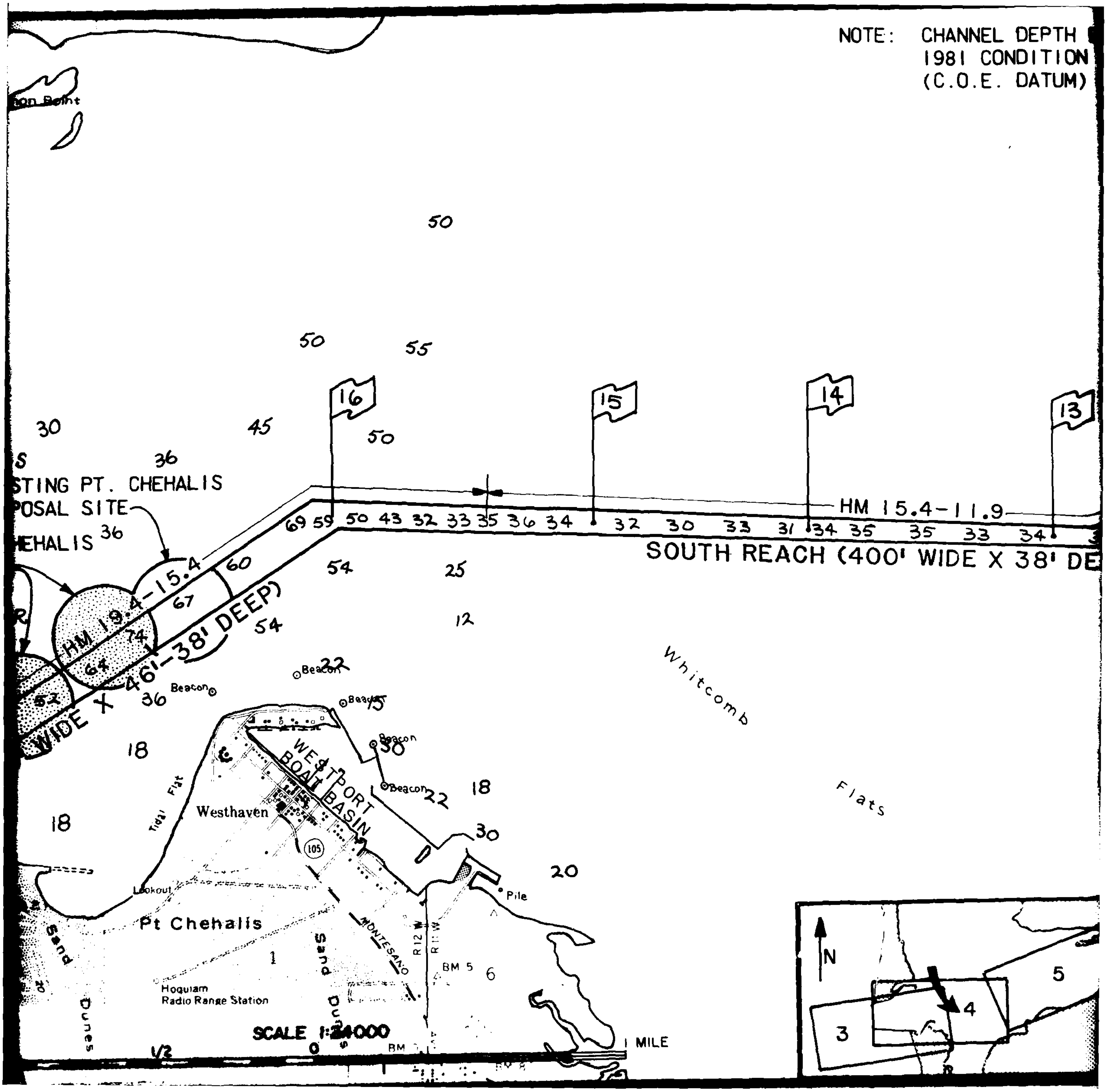

NOTE: CHANNEL DEPTH BASED ON
1981 CONDITION SURVEY (MLLW).
(C.O.E. DATUM)
HM 22-19.4
OUTER BAR REACH
(1000' WIDE X 46' DEEP)
20
21
LEGEND
HM - HARBOR MILES
RM - RIVER MILES
1/2


POINT BROWN
NORTH JETTY
GRAYS HARBOR
PROPOSED PT. CHEHALIS DISPOSAL SITES
PROPOSED SOUTH JETTY DISPOSAL SITE
ENTRANCE REACH (VARIES 100'-600' WIDE X 46'-38')
JETTY RUINS (SUBMERGED)
SOUTH JETTY
Matchline
REACH
X 46' DEEP)
HM 19.4
Sand Dunes
SCALE 1:24000
1/2
0
1 MILE
N
3
4
5

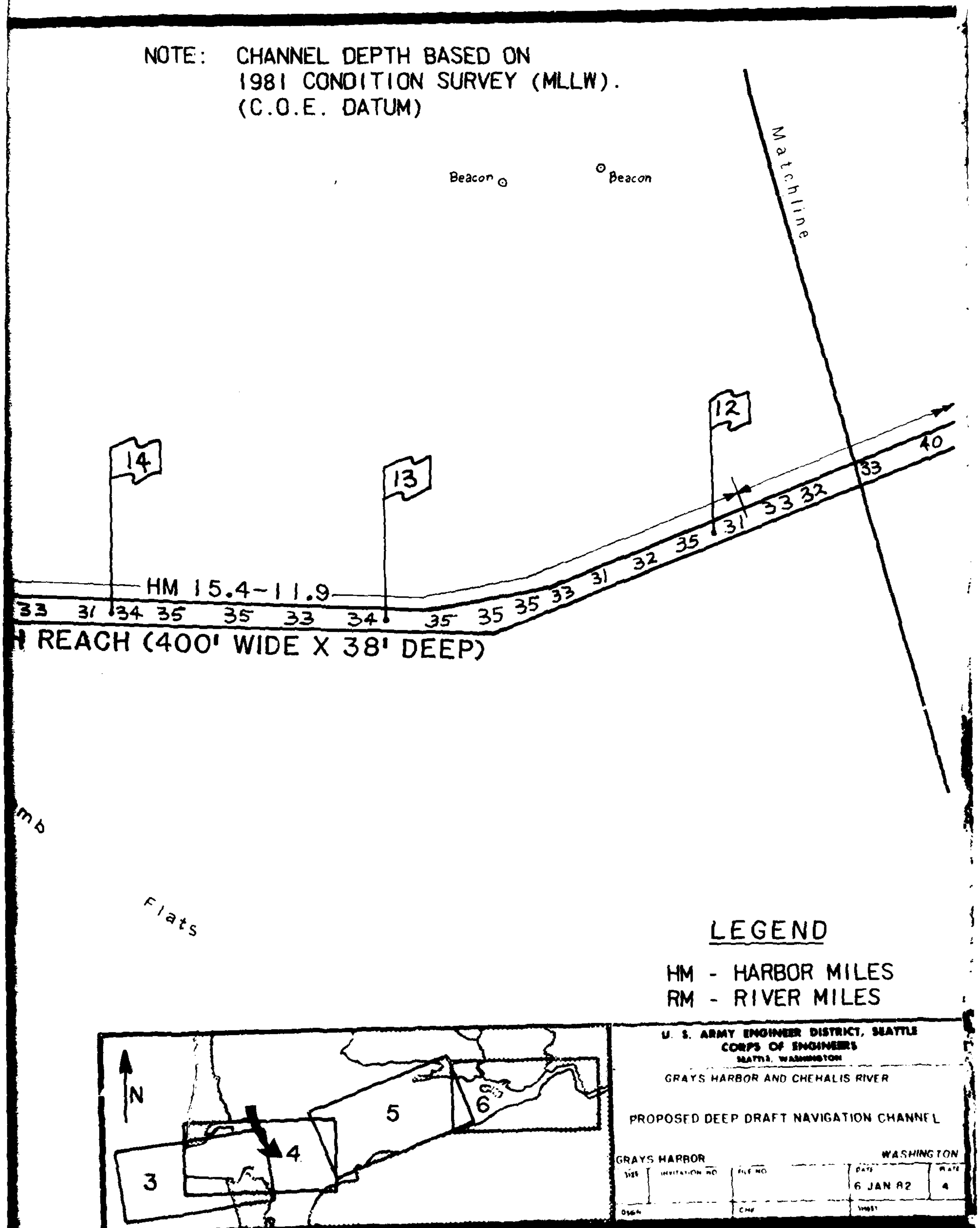

PROPOSED PT. CHEHALIS
DISPOSAL SITES
EXISTING PT. CHEHALIS
DISPOSAL SITE.
ED SOUTH JETTY
L SITE
HM 19.4-15.4
00'-600' WIDE X 46'-38' DEEP)
G R A Y S
H A R B O R
Beacon
Pile
WESTPORT
BOAT BASIN
Westhaven
Tidal Flat
Lookout
Pt Chehalis
Sand
Dunes
Hoquiam
Radio Range Station
MONTESANO
R12 W
R11 W
BM 5
16
17
N
3
4
5
6
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON
GRAYS HARBOR AND CHEHALIS RIVER
PROPOSED DEEP DRAFT NAVIGATION CHANNEL
GRAYS HARBOR
WASHINGTON
6 JAN 82
3



POINT BROWN
MUD
Damon Point
SUBMERGED JETTY
GRAYS HARBOR
EXISTING PT. CHEHALIS DISPOSAL SITE
PROPOSED PT. CHEHALIS DISPOSAL SITES
PROPOSED SOUTH JETTY DISPOSAL SITE
HM 19.4-15.4
ENTRANCE REACH (VARIES 100'-600' WIDE X 46'-38' DE
(SUBMERGED)
SOUTH JETTY
Matchline
Tidal Flat
Westha
Lookout
Pt Chehal
Sand
Dunes
Hoquiam Radio Range
Beacon

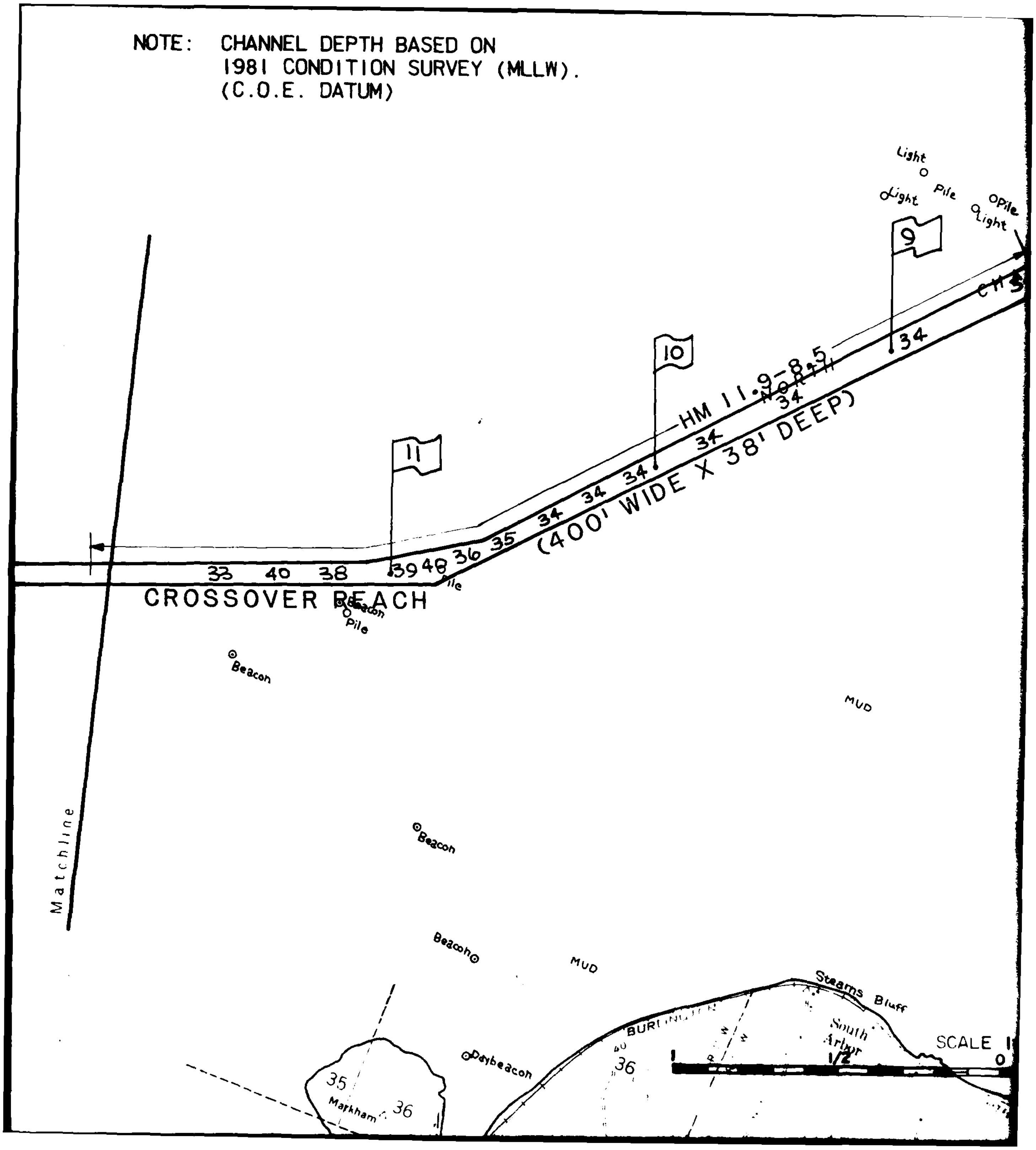


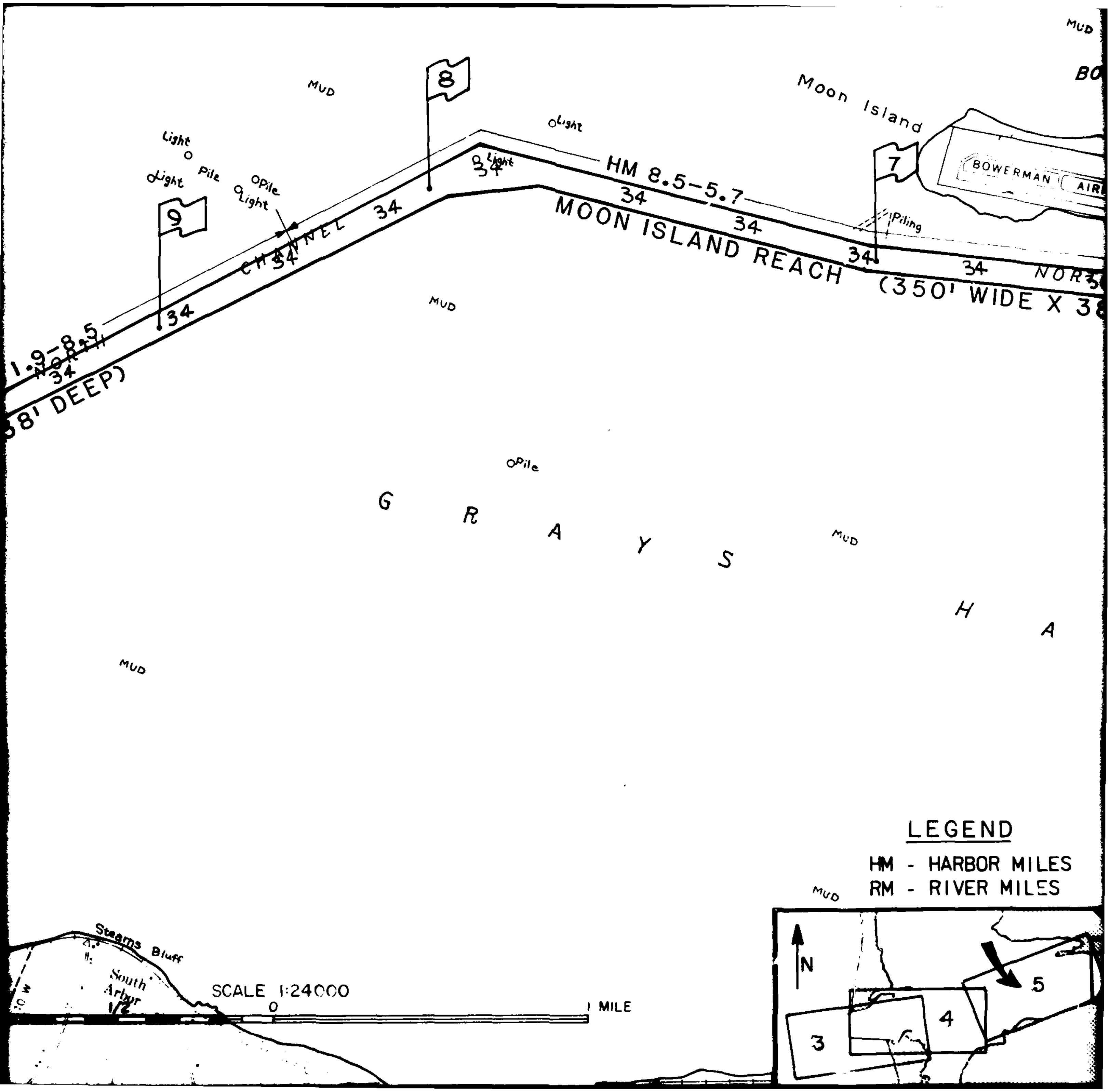
NOTE: CHANNEL DEPTH
1981 CONDITION
(C.O.E. DATUM)
STING PT. CHEHALIS
POSAL SITE
EHALIS
HM 19.4-15.4
WIDE X 461-38' DEEP)
HM 15.4-11.9
SOUTH REACH (400' WIDE X 38' DE
Whitcomb
Flats
WESTPORT
BOAT BASIN
Westhaven
Tidal Flat
Beacon
Pile
Lookout
Pt Chehalis
Sand
Dunes
MONTESANO
Hoquiam
Radio Range Station
BM 5
SCALE 1:24000
1/2
0
1 MILE
N
3
4
5



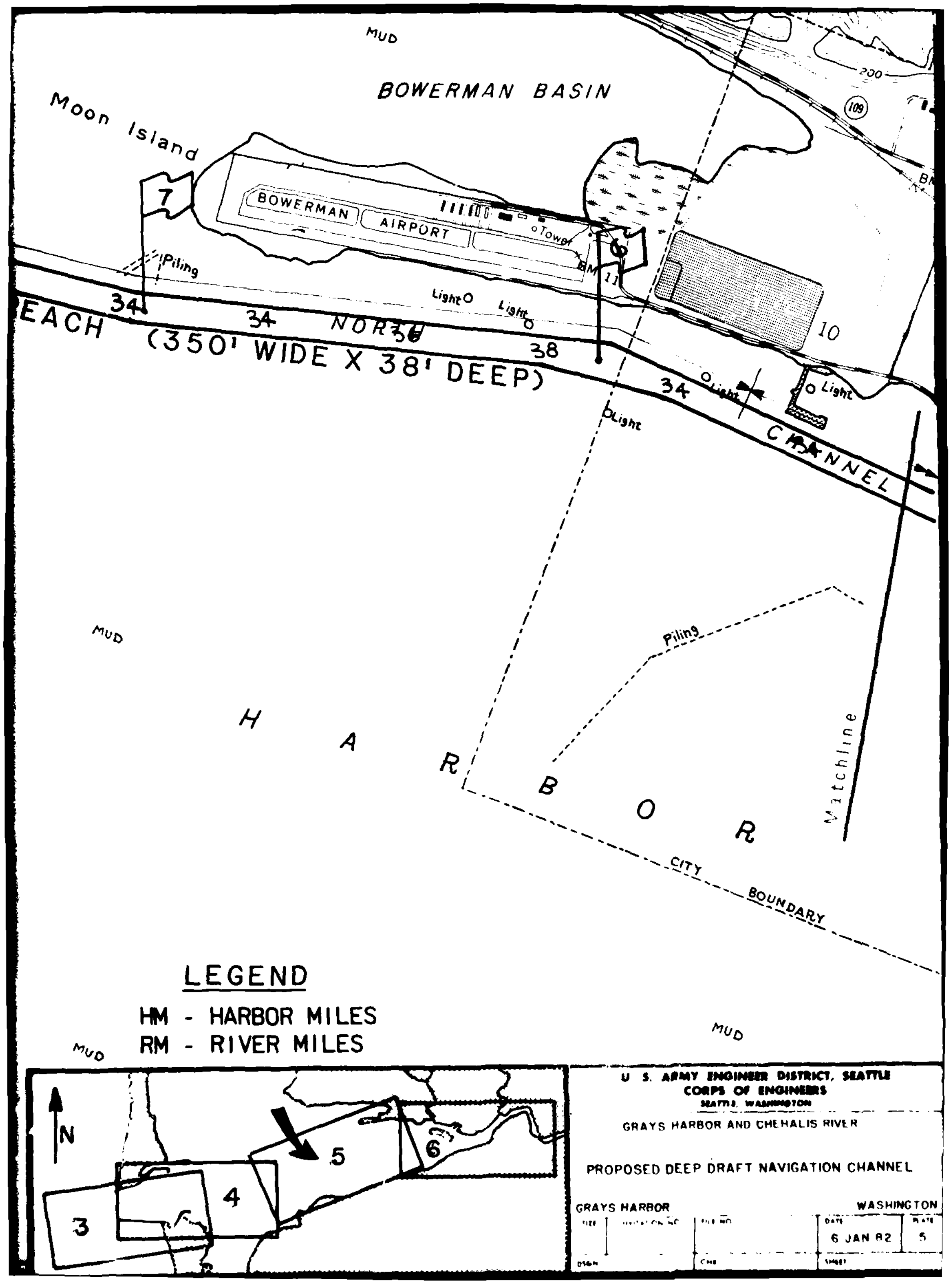
NOTE: CHANNEL DEPTH BASED ON
1981 CONDITION SURVEY (MLLW).
(C.O.E. DATUM)
Beacon
Beacon
Matchline
14
13
12
HM 15.4-11.9
33 31 34 35 35 33 34 35 35 35 33 31 32 35 31 33 32 33 40
REACH (400' WIDE X 38' DEEP)
Flats
LEGEND
HM - HARBOR MILES
RM - RIVER MILES
N
3
4
5
6
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON
GRAYS HARBOR AND CHEHALIS RIVER
PROPOSED DEEP DRAFT NAVIGATION CHANNEL
GRAYS HARBOR
WASHINGTON
DATE
6 JAN 82
PLATE
4

NOTE: CHANNEL DEPTH BASED ON
1981 CONDITION SURVEY (MLLW).
(C.O.E. DATUM)



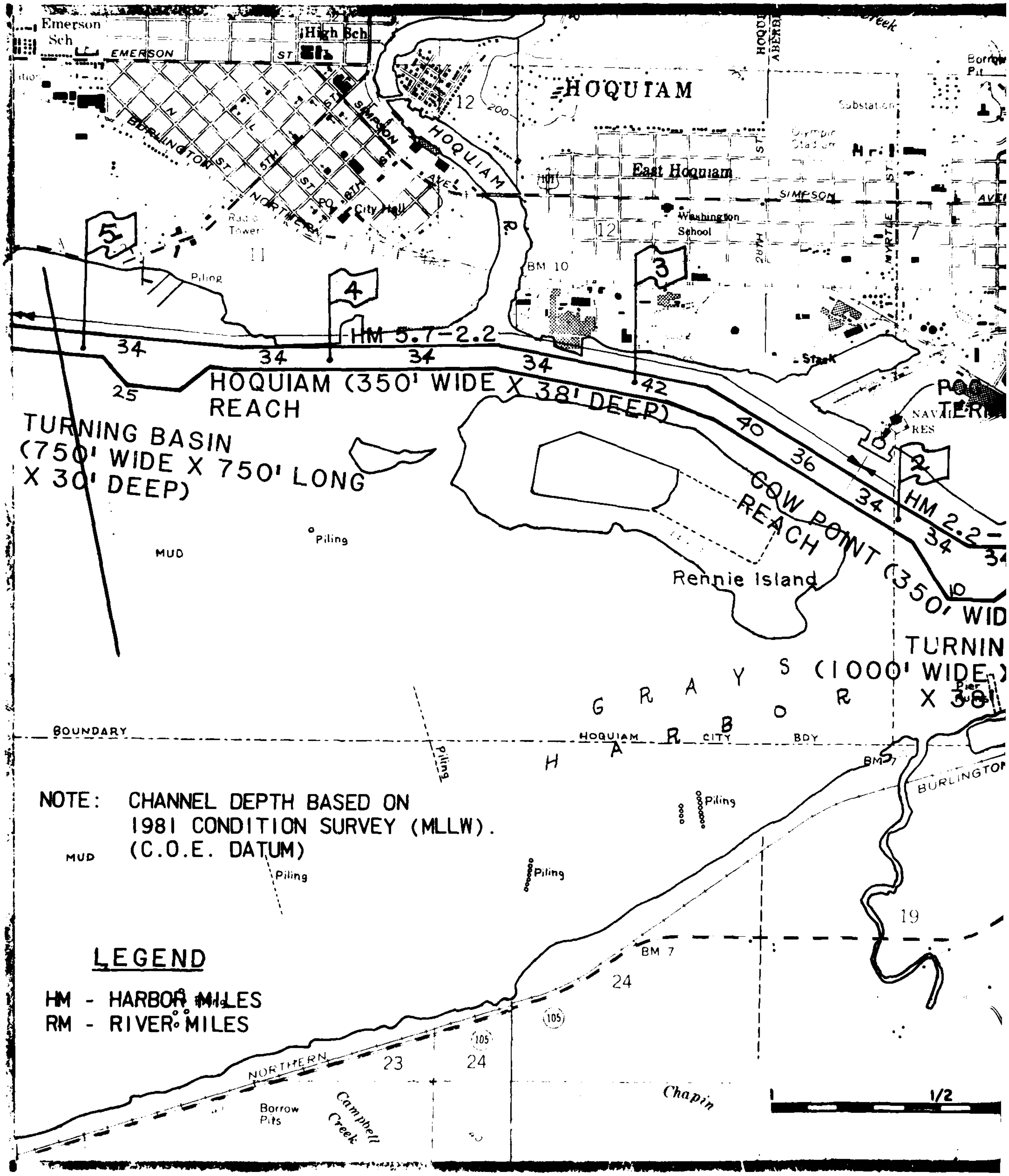


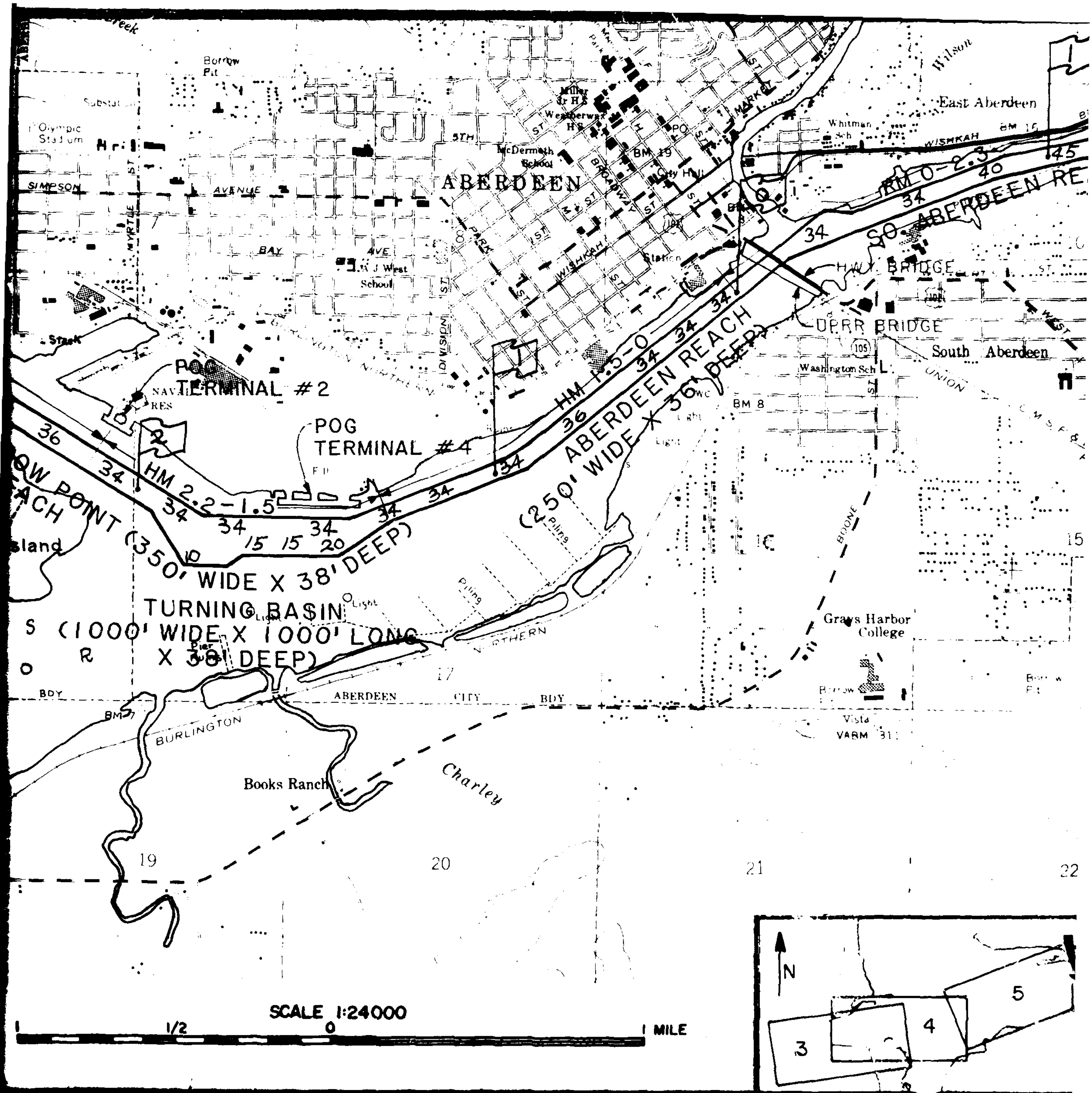
MUD
Moon Island
BOWERMAN
AIR
HM 8.5-5.7
MOON ISLAND REACH
(350' WIDE X 38' DEEP)
NORTH CHANNEL
1.9-8.5
34
Light
Pile
Piling
9
8
7
GRAYS HARBOR
Steams Bluff
South Arbor
SCALE 1:24000
0
1 MILE
LEGEND
HM - HARBOR MILES
RM - RIVER MILES
N
3
4
5



MUD
BOWERMAN BASIN
Moon Island
7
BOWERMAN
AIRPORT
Tower
6
BM 11
Piling
34
34
NORTH
36
38
Light
Light
Light
Light
Light
REACH (350' WIDE X 38' DEEP)
34
CHANNEL
10
200
109
MUD
HARBOR
Piling
Matchline
CITY BOUNDARY
MUD
MUD
LEGEND
HM - HARBOR MILES
RM - RIVER MILES
N
3
4
5
6
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON
GRAYS HARBOR AND CHEHALIS RIVER
PROPOSED DEEP DRAFT NAVIGATION CHANNEL
GRAYS HARBOR
WASHINGTON
6 JAN 82
5

PRECEDING PAGE BLANK-NOT FILMED

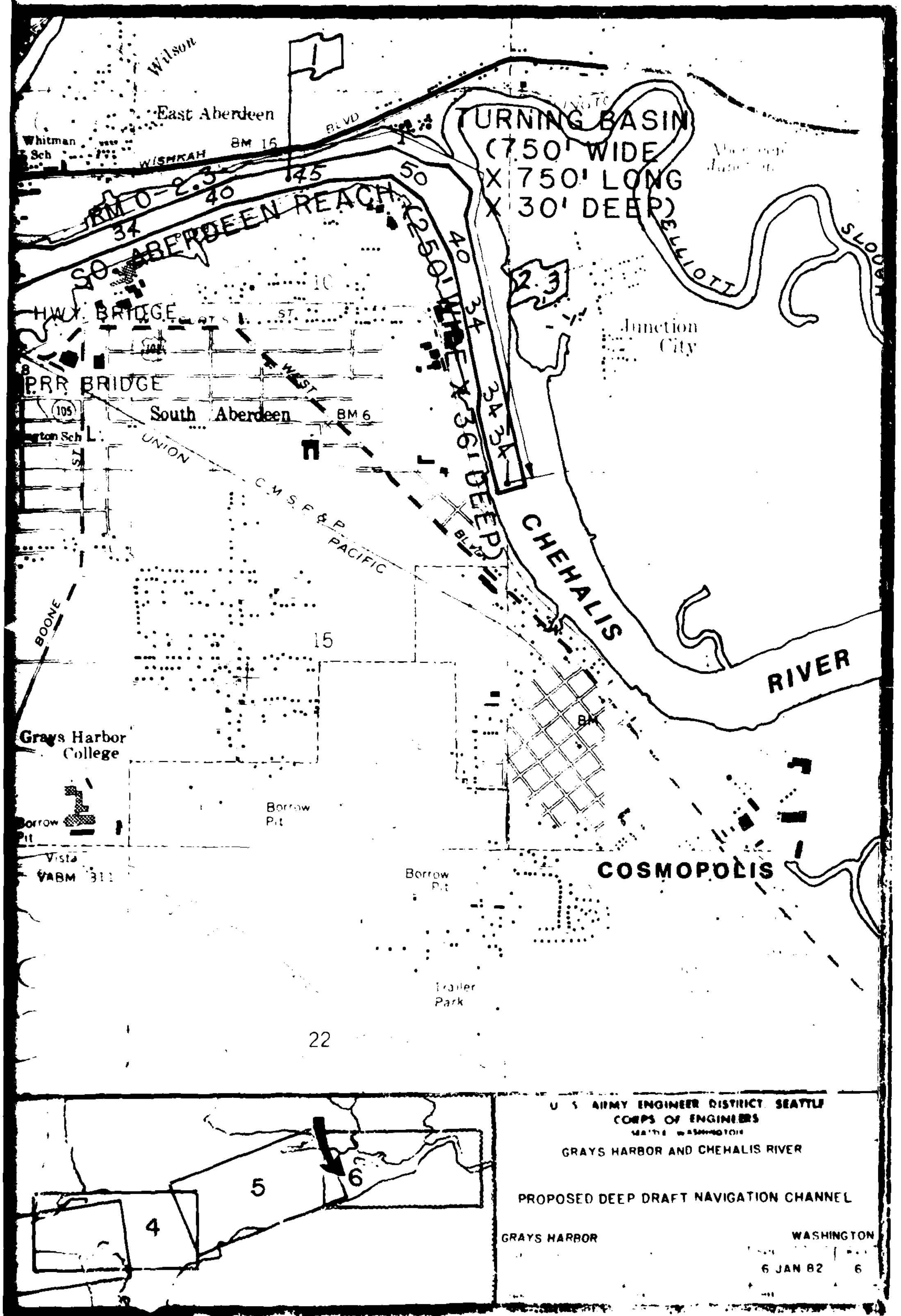



ABERDEEN
East Aberdeen
South Aberdeen
POG TERMINAL #2
POG TERMINAL #4
HM 2.2-1.5
HM 1.5-0
RM 0-2.3
ABERDEEN REACH (250' WIDE X 36' DEEP)
SO. ABERDEEN REACH
HWY. BRIDGE
UPRR BRIDGE
TURNING BASIN (1000' WIDE X 1000' LONG X 38' DEEP)
(350' WIDE X 38' DEEP)
Grays Harbor College
Books Ranch
Charley
Miller Jr H S
Weatherwax H S
McDermoth School
City Hall
Washington Sch
Whitman Sch
A J West School
Olympic Stadium
Borrow Pit
SIMPSON AVENUE
BAY AVE
BROADWAY
DIVISION ST
MYRTLE ST
WISHKAH
MARKET ST
PARK ST
BURLINGTON
NORTHERN
ABERDEEN CITY BDY
BM 8
BM 19
BM 15
BM 7
Light
Piling
Pier
Station
19
20
21
22
SCALE 1:24000
1/2
0
1 MILE
N
3
4
5

AD-A115 779 CORPS OF ENGINEERS SEATTLE WA SEATTLE DISTRICT F/G 13/2
INTERIM FEASIBILITY REPORT AND DRAFT ENVIRONMENTAL IMPACT STATE--ETC(U)
JUN 82

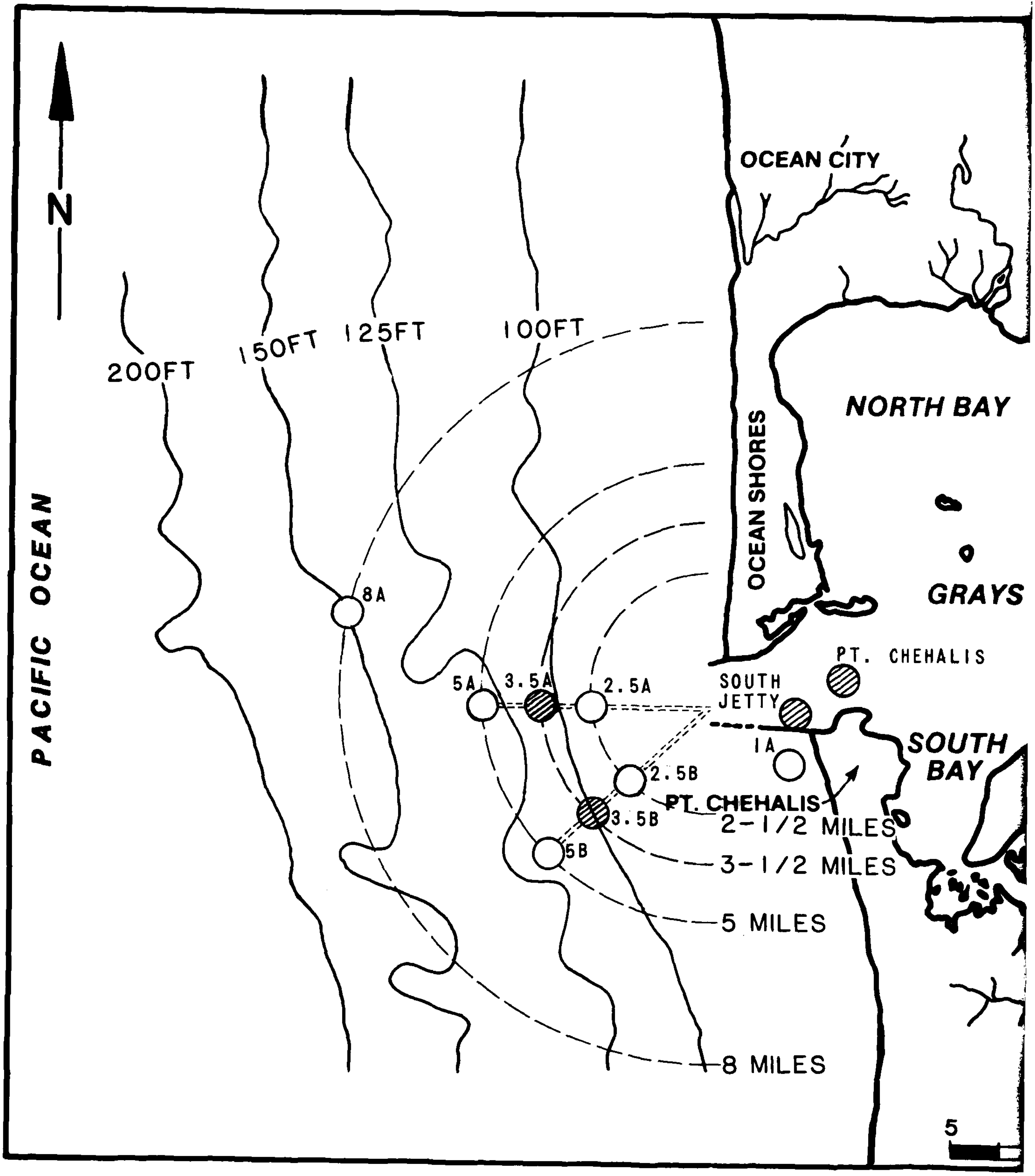
UNCLASSIFIED NL

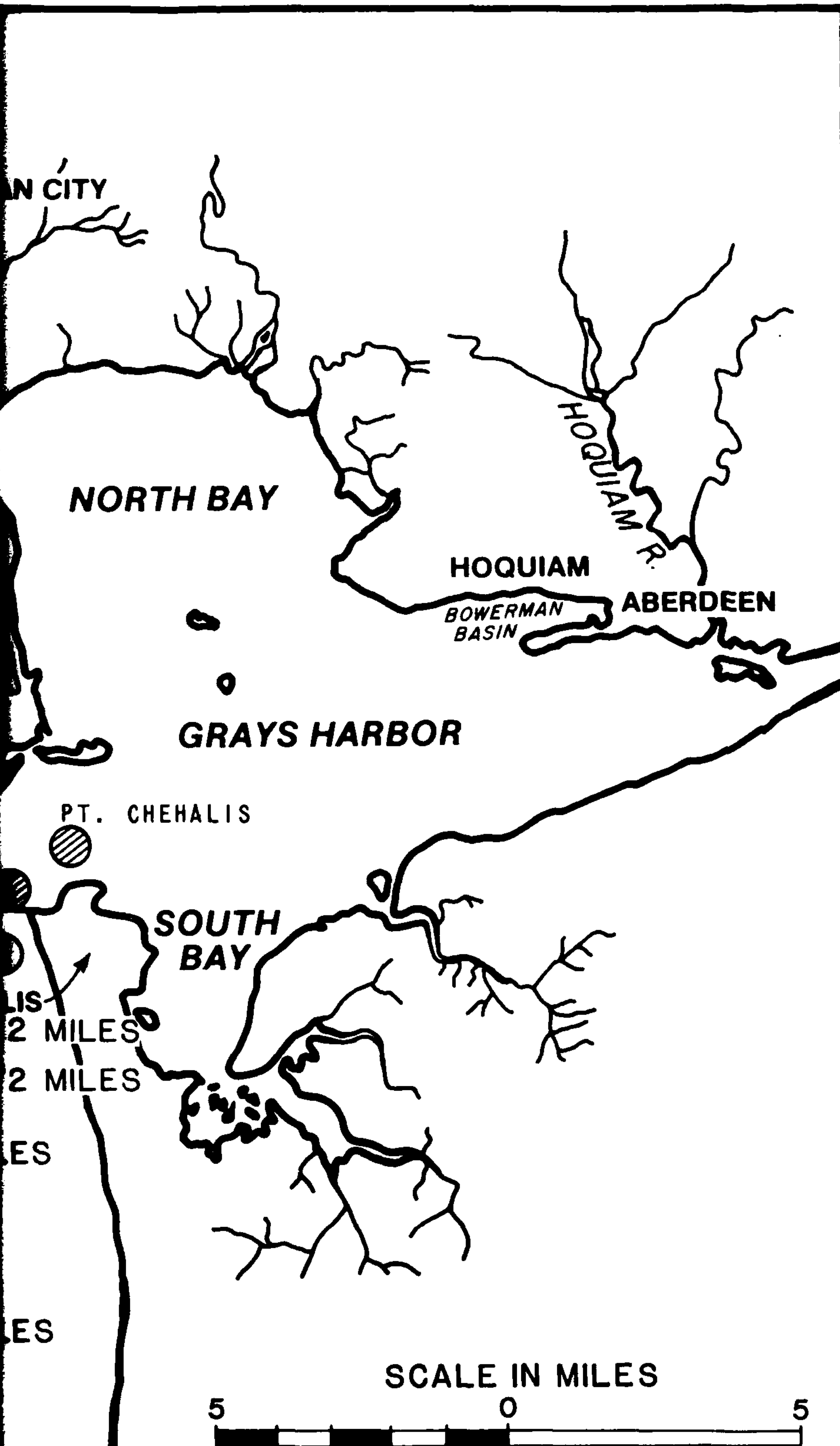
3 OF 6
AD A
115 779

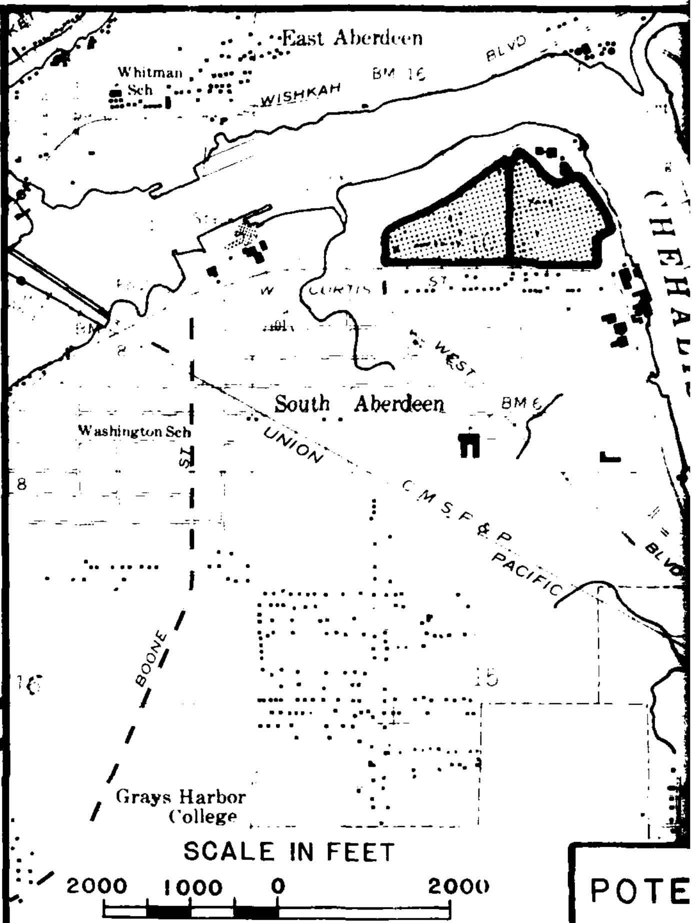


TURNING BASIN
(750' WIDE
X 750' LONG
X 30' DEEP)
SO. ABERDEEN REACH (250' WIDE X 36' DEEP)
RM 0-2.3
East Aberdeen
Wilson
Whitman Sch
WISHKAH
BLVD
BM 16
HWY. BRIDGE
PRR BRIDGE
South Aberdeen
BM 6
UNION
C.M.S.P.&P.
PACIFIC
BOONE
Junction City
ELLIOTT
SLOUGH
CHEHALIS
RIVER
COSMOPOLIS
Grays Harbor College
Borrow Pit
Trailer Park
Vista
VABM 311
15
22
4
5
6
U.S. ARMY ENGINEER DISTRICT SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON
GRAYS HARBOR AND CHEHALIS RIVER
PROPOSED DEEP DRAFT NAVIGATION CHANNEL
GRAYS HARBOR
WASHINGTON
6 JAN 82
6

PRECEDING PAGE BLANK-NOT FILMED







POTE

LEGEND

UPLAND DISPOSAL SITE FOR ANY MATERIAL FOUND UNSUITABLE FOR OPEN WATER DISPOSAL (SOUTH ABERDEEN SITE)

WETLAND SITES EVALUATED BUT NOT PROPOSED FOR DREDGED MATERIAL DISPOSAL (JUNCTION CITY SITES)

POTENTIAL OCEAN DISPOSAL SITES

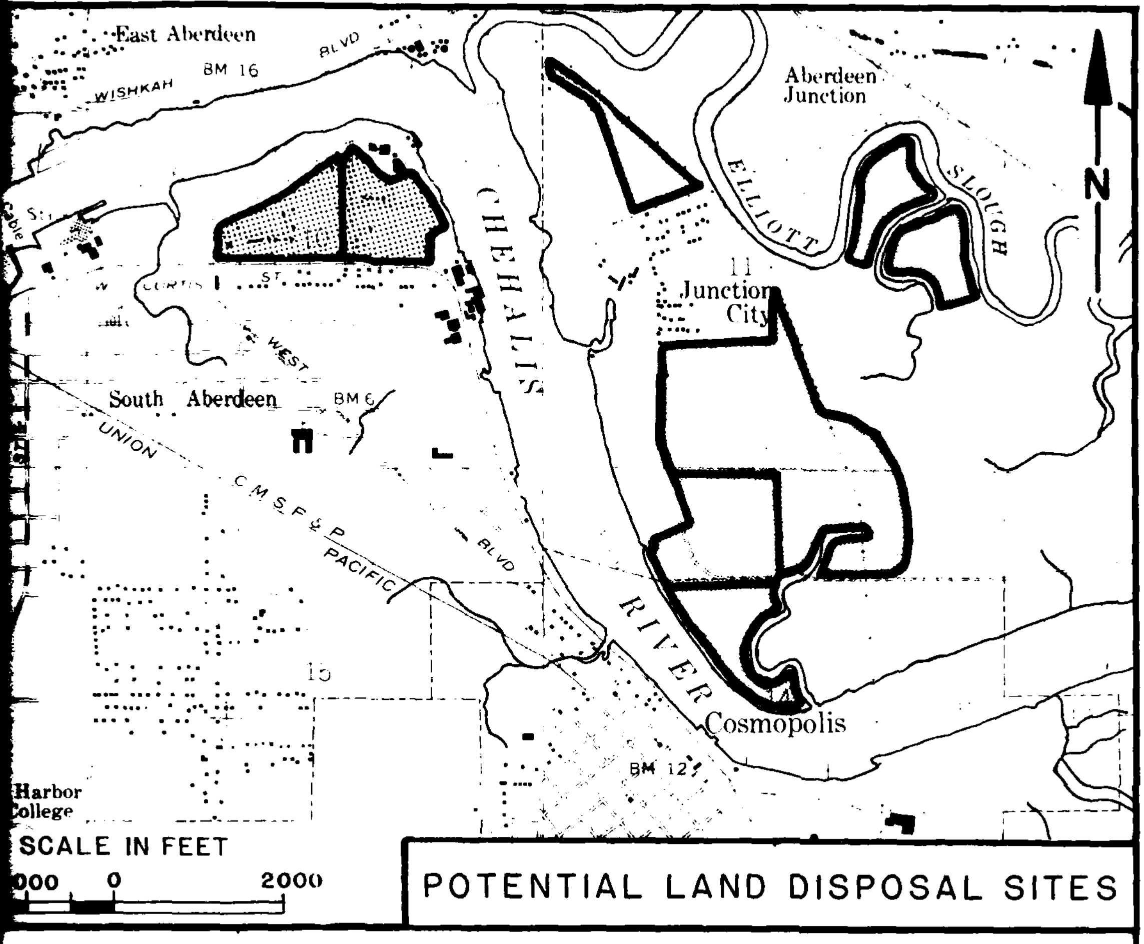
RECOMMENDED DISPOSAL SITES FOR FEASIBILITY STUDY

D

GRAY

SIZE

DSGN.



POTENTIAL LAND DISPOSAL SITES

LEGEND

PLAND DISPOSAL SITE FOR
Y MATERIAL FOUND
SUITABLE FOR OPEN WATER
SPOSAL (SOUTH ABERDEEN
TE)

ETLAND SITES EVALUATED
T NOT PROPOSED FOR
EDGED MATERIAL DISPOSAL
JUNCTION CITY SITES)

TENTIAL OCEAN DISPOSAL
TES

ECOMMENDED DISPOSAL
TES FOR FEASIBILITY
UDY

DISPOSAL AREA TRAFFIC LANES

U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

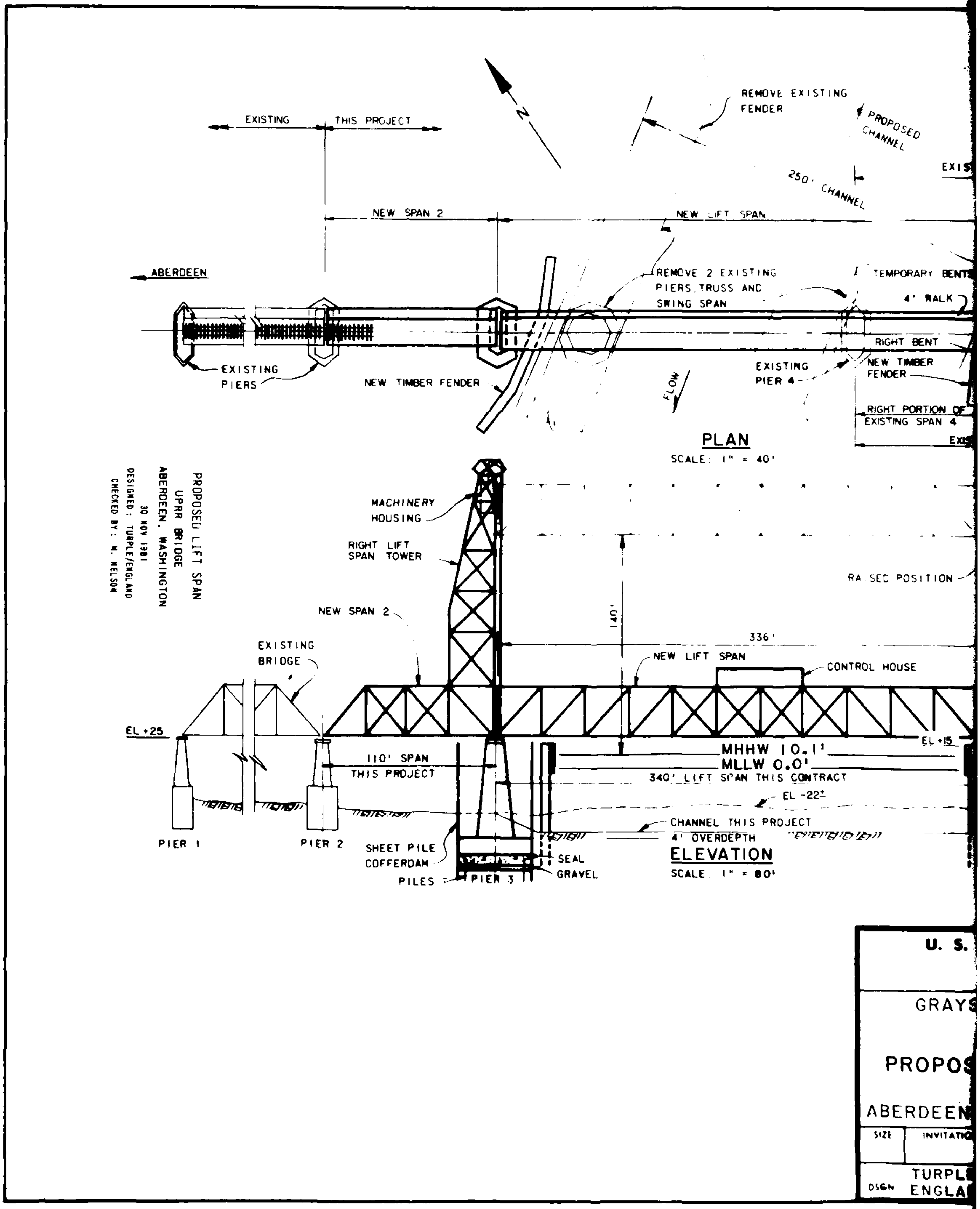
GRAYS HARBOR AND CHEHALIS RIVER

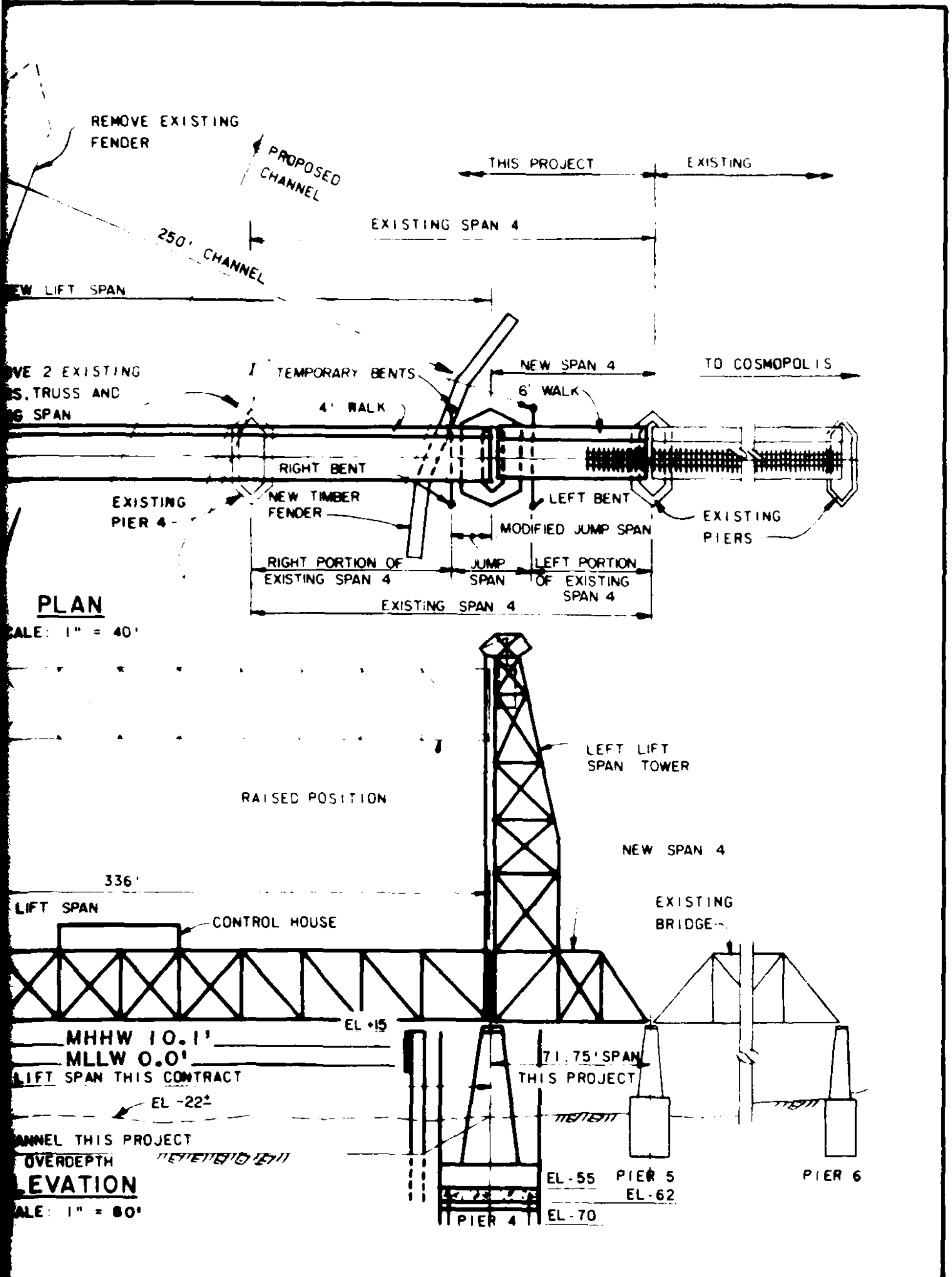
DREDGE DISPOSAL ALTERNATIVES AND RECOMMEDED SITES

GRAYS HARBOR — WASHINGTON

SIZE	INVITATION NO	FILE NO	DATE	PLATE
			6 JAN 82	7
DSGN.		CHK	SHEET	

PRECEDING PAGE BLANK-NOT FILMED





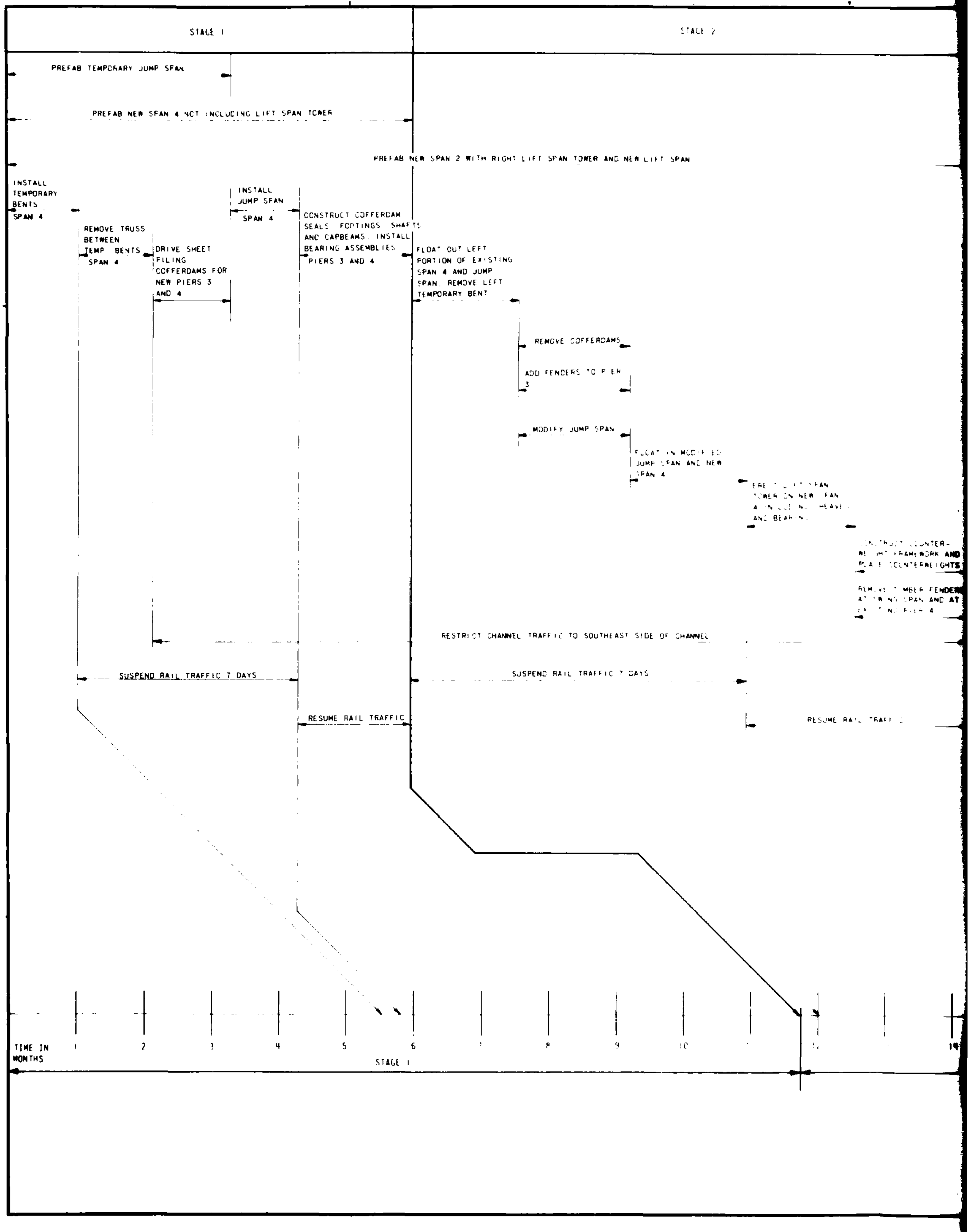
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

GRAYS HARBOR AND CHEHALIS RIVER

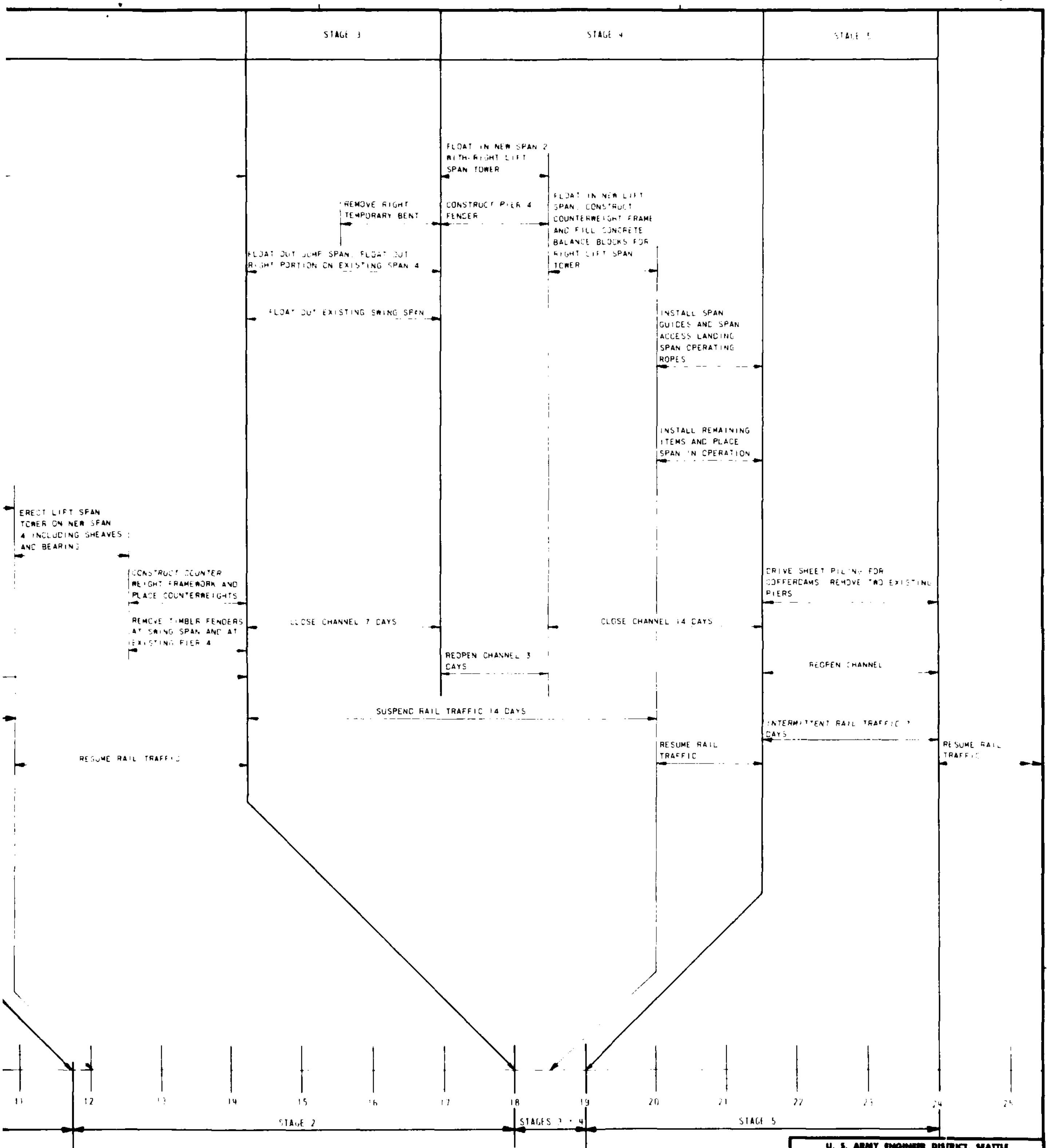
PROPOSED LIFT SPAN UPRR BRIDGE

ABERDEEN WASHINGTON

SIZE	INVITATION NO	FILE NO	DATE	PLATE
			30 NOV 81	8
DSGN	TURPLE ENGLAND	CHK M. NELSON	SHEET	



STAGE 1
STAGE 2
PREFAB TEMPORARY JUMP SPAN
PREFAB NEW SPAN 4 NOT INCLUDING LIFT SPAN TOWER
PREFAB NEW SPAN 2 WITH RIGHT LIFT SPAN TOWER AND NEW LIFT SPAN
INSTALL TEMPORARY BENTS SPAN 4
INSTALL JUMP SPAN SPAN 4
REMOVE TRUSS BETWEEN TEMP. BENTS SPAN 4
DRIVE SHEET PILING COFFERDAMS FOR NEW PIERS 3 AND 4
CONSTRUCT COFFERDAM SEALS, FOOTINGS, SHAFTS AND CAPBEAMS. INSTALL BEARING ASSEMBLIES PIERS 3 AND 4
FLOAT OUT LEFT PORTION OF EXISTING SPAN 4 AND JUMP SPAN. REMOVE LEFT TEMPORARY BENT
REMOVE COFFERDAMS
ADD FENDERS TO PIER 3
MODIFY JUMP SPAN
RESTRICT CHANNEL TRAFFIC TO SOUTHEAST SIDE OF CHANNEL
SUSPEND RAIL TRAFFIC 7 DAYS
SUSPEND RAIL TRAFFIC 7 DAYS
RESUME RAIL TRAFFIC
TIME IN MONTHS
1
2
3
4
5
6
8
9
STAGE 1



U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

GRAY HARBOR
CONSTRUCTION SCHEDULE
UNION PACIFIC RAILROAD BRIDGE NO 5333
RECONSTRUCTION AT EXISTING LOCATION

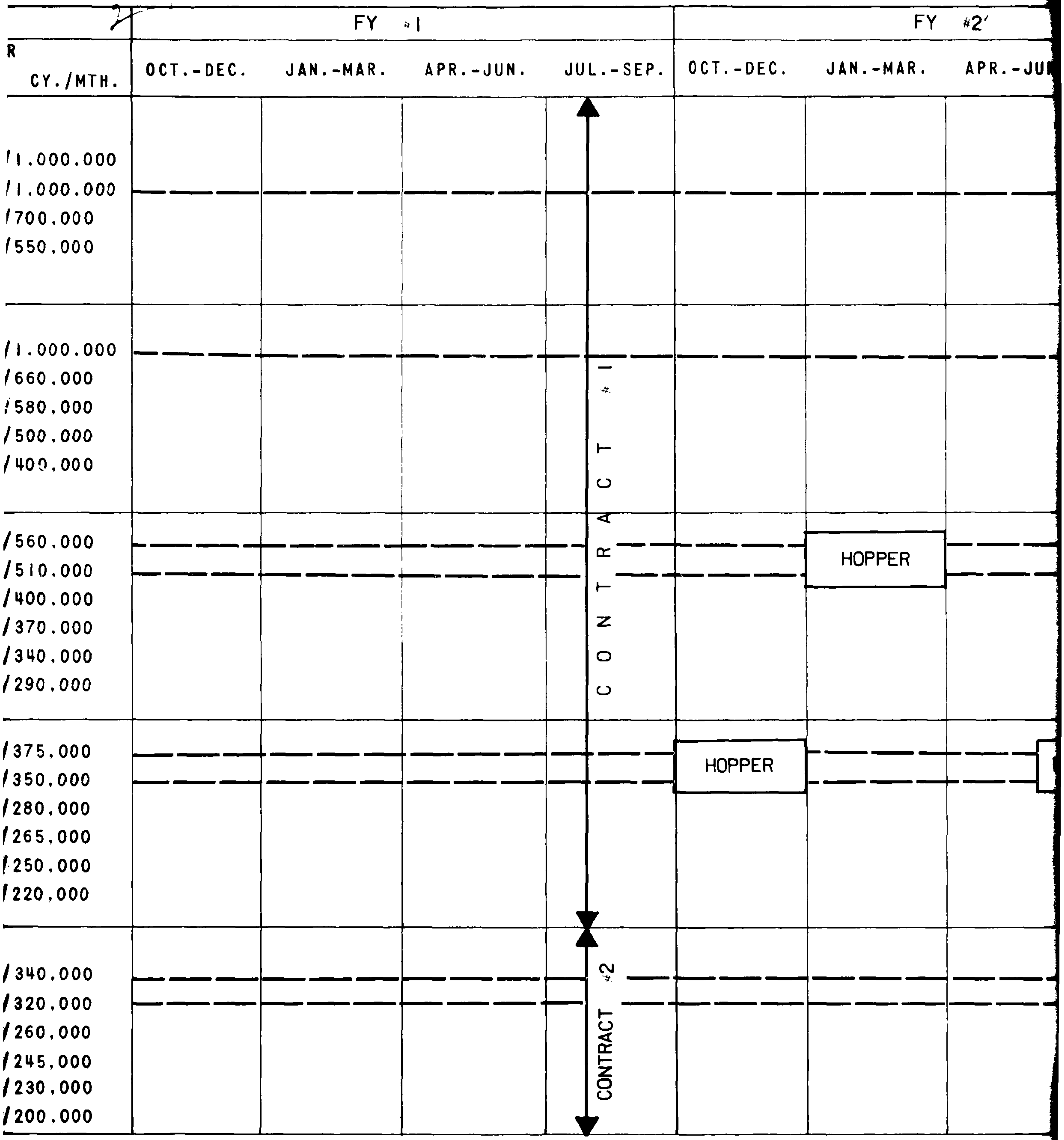
ABERDEEN WASHINGTON

Garrett L. Johnson

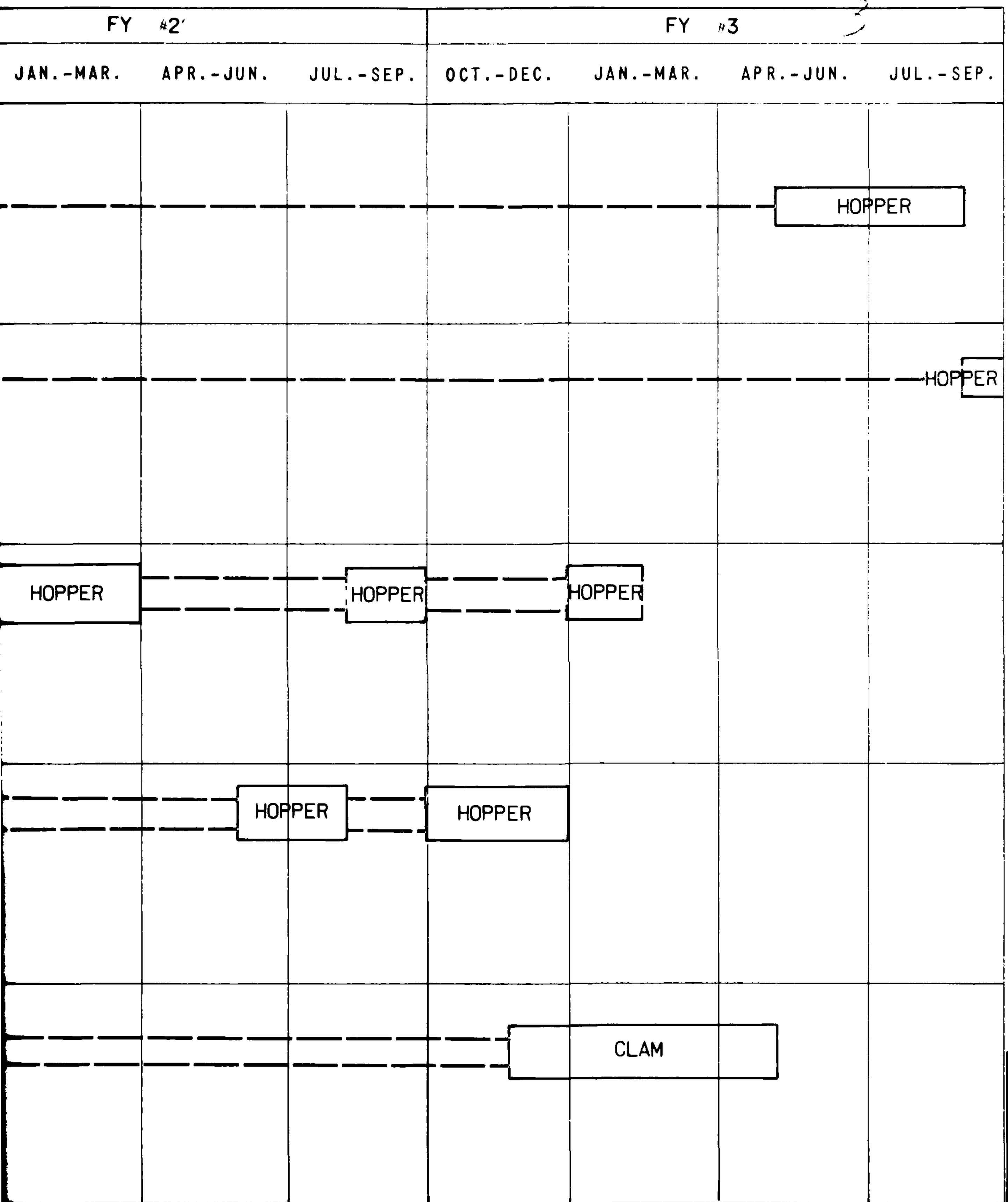
DRAWN ENGLAND | CHK M. NELSON | DATE 6 JAN 82 | 9

REACH (QTY./MAT'L.)	DISPOSAL LOCATION	CLAMSHELL $/CY. CY./MTH.*	HOPPER $/CY. CY./MTH.	OCT.-DEC
BAR 3.000.000 CY. Fine to coarse sands Plus rehandling of 1.000.000 CY. of sands	2½ Mile	N.A.	1.10/1.000.000	
	3½ Mile	N.A.	1.25/1.000.000	
	5 Mile	N.A.	1.65/700.000	
	8 Mile	N.A.	2.20/550.000	
ENTRANCE 200.000 CY. Medium sands	South Jetty	N.A.	1.25/1.000,000	
	2½ Mile	N.A.	1.80/660,000	
	3½ Mile	N.A.	2.00/580,000	
	5 Mile	N.A.	2.35/500.000	
	8 Mile	N.A.	2.90/400,000	
SOUTH REACH 3.400,000 CY. Fine sands	Pt. Chehalis	2.20/300,000	1.35/560.000	
	South Jetty	2.30/290.000	1.45/510.000	
	2½ Mile	2.50/270.000	1.95/400.000	
	3½ Mile	2.55/265,000	2.05/370.000	
	5 Mile	2.65/260,000	2.20/340.000	
	8 Mile	2.80/250.000	2.55/290.000	
CROSSOVER 2,900,000 CY. 70% Fine sands 30% Silts	Pt. Chehalis	2.25/300.000	1.75/375.000	
	South Jetty	2.35/290.000	1.85/350.000	
	2½ Mile	2.70/260,000	2.30/280.000	
	3½ Mile	2.75/255,000	2.25/265.000	
	5 Mile	2.80/250.000	2.20/250.000	
	8 Mile	2.95/240,000	3.00/220.000	
MOON ISLAND 1,900,000 CY. 70% Fine sands 30% Silts	Upland Pt. Chehalis	2.30/300,000	2.00/340,000	
	South Jetty	2.40/290,000	2.10/320.000	
	2½ Mile	2.75/250,000	2.55/260,000	
	3½ Mile	2.80/245,000	2.70/245.000	
	5 Mile	2.90/240,000	2.90/230.000	
	8 Mile	3.00/230,000	3.30/200.000	

*CY./MTH. = Cubic yards per month (volume of material which can be dredged from a particular reach per month).



ch can be dredged



NOTE:

U. S.

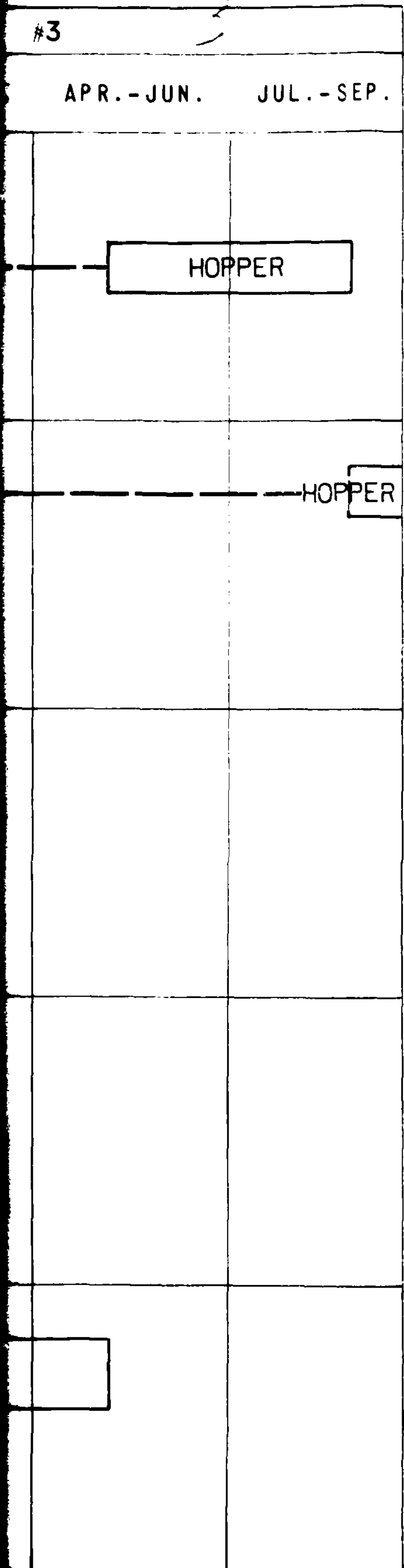
GRAY

DRE

GRAYS HAR

SIZE	INVITATIO

DSGN



NOTE: Gravels to Pt. Chehalis at a cost of $5.00/CY.

U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

GRAYS HARBOR AND CHEHALIS RIVER

DREDGING QUANTITIES, COSTS, AND SCHEDULE

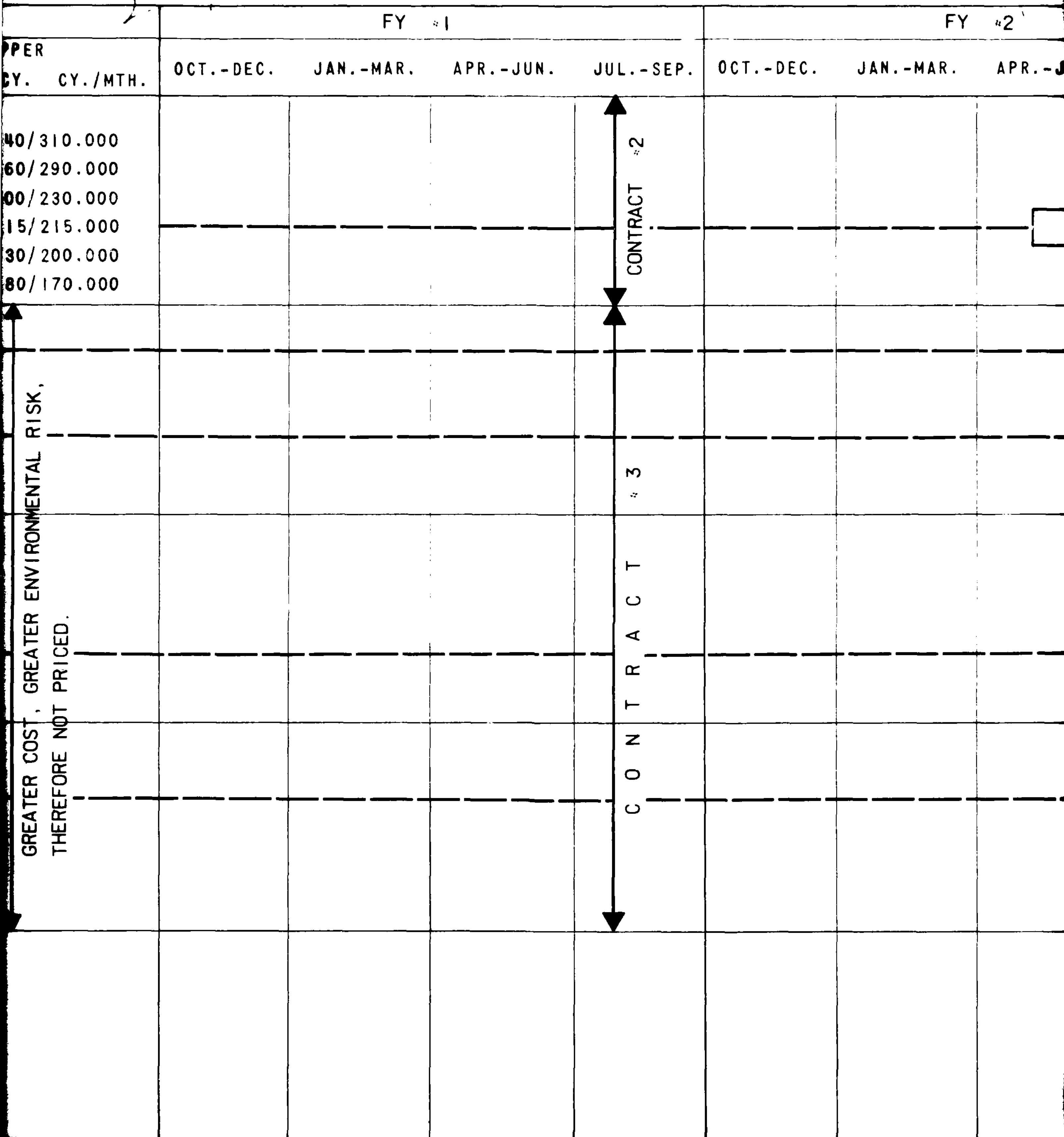
GRAYS HARBOR — WASHINGTON

SIZE	INVITATION NO	FILE NO	DATE	PLATE
			29 JAN 82	10

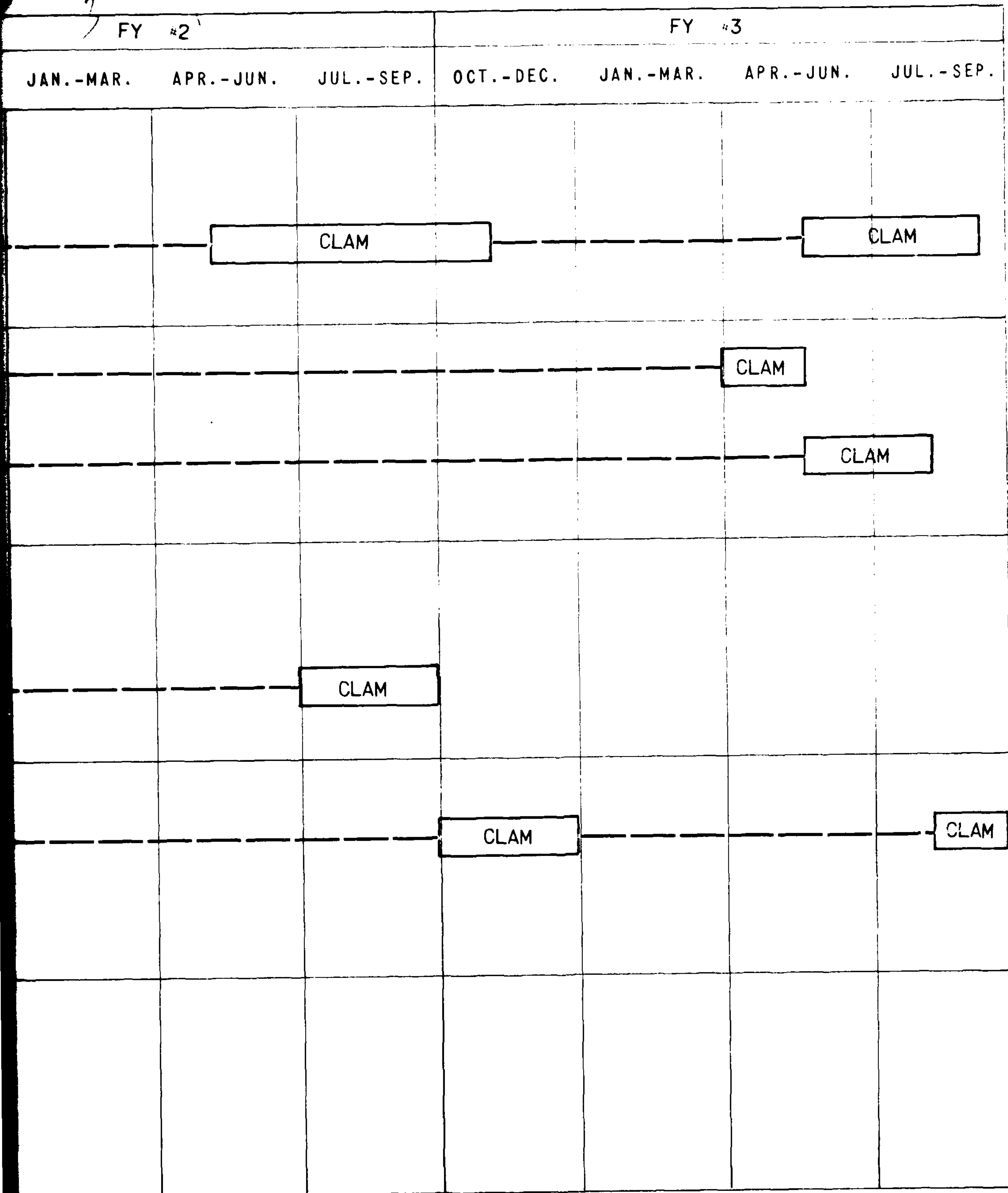
DSGN	CHK	SHEET 1 of 2

REACH (QTY./MAT'L.)	DISPOSAL LOCATION	CLAMSHELL $/CY. CY./MTH.*	HOPPER $/CY. CY./MTH.	OCT.-DEC.
HOQUIAM 2.150.000 CY. 60% Fine sands 40% Silts	Upland			
	Pt. Chehalis	2.35/300.000	2.40/310.000	
	South Jetty	2.45/290.000	2.60/290.000	
	2½ Mile	2.90/240.000	3.00/230.000	
	3½ Mile	3.00/220.000	3.15/215.000	
	5 Mile	3.10/230.000	3.30/200.000	
	8 Mile	3.30/210.000	3.80/170.000	
COW POINT 700.000 CY. 200.000 CY. Gravel 500.000 CY. 25% Fine sands 75% Silts	Upland	(see note)	GREATER COST, GREATER ENVIRONMENTAL RISK, THEREFORE NOT PRICED.	
	Pt. Chehalis	2.45/290.000		
	South Jetty	2.55/280.000		
	2½ Mile	3.15/230.000		
	3½ Mile	3.25/220.000		
	5 Mile	3.40/215.000		
	8 Mile	3.70/195.000		
ABERDEEN 550.000 CY. 50% Fine/Med. sands 50% Silts	Upland			
	Pt. Chehalis	2.55/280.000		
	South Jetty	2.70/270.000		
	2½ Mile	3.40/220.000		
	3½ Mile	3.50/210.000		
	5 Mile	3.70/200.000		
	8 Mile	4.10/180.000		
SOUTH ABERDEEN 1.300.000 CY. 50% Fine sands 50% Silts	Upland			
	Pt. Chehalis	2.80/260.000		
	South Jetty	2.95/250.000		
	2½ Mile	3.85/190.000		
	3½ Mile	4.10/180.000		
	5 Mile	4.30/170.000		
	8 Mile	5.20/140.000		

*CY./MTH. = Cubic yards per month (volume of material which can be dredged from a particular reach per month).



ich can be dredged



NOTE

U.

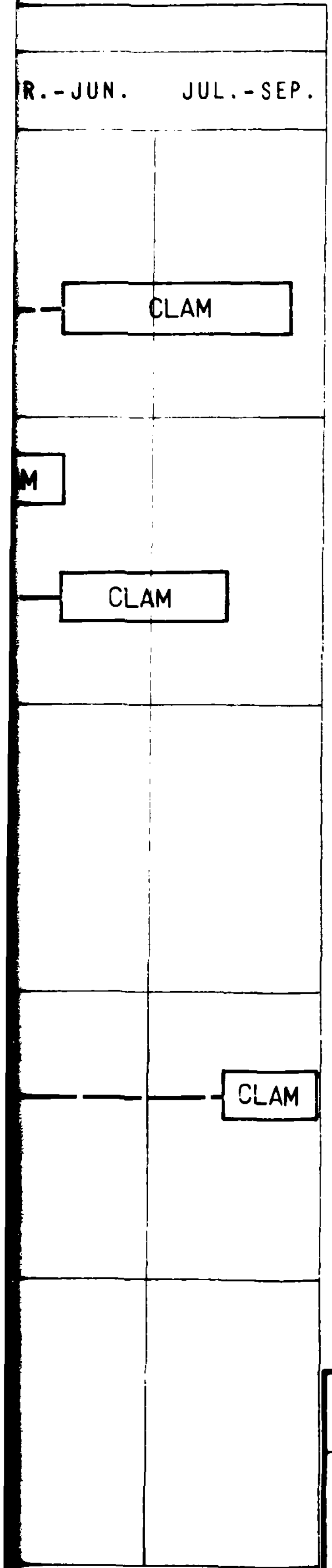
GRA

DR

GRAYS HA

SIZE

DSGN



NOTE: Gravels to Pt. Chehalis at a cost of $3.50/CY.

NOTE: Gravels to Pt. Chehalis at a cost of $5.00/CY.

U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

GRAYS HARBOR AND CHEHALIS RIVER

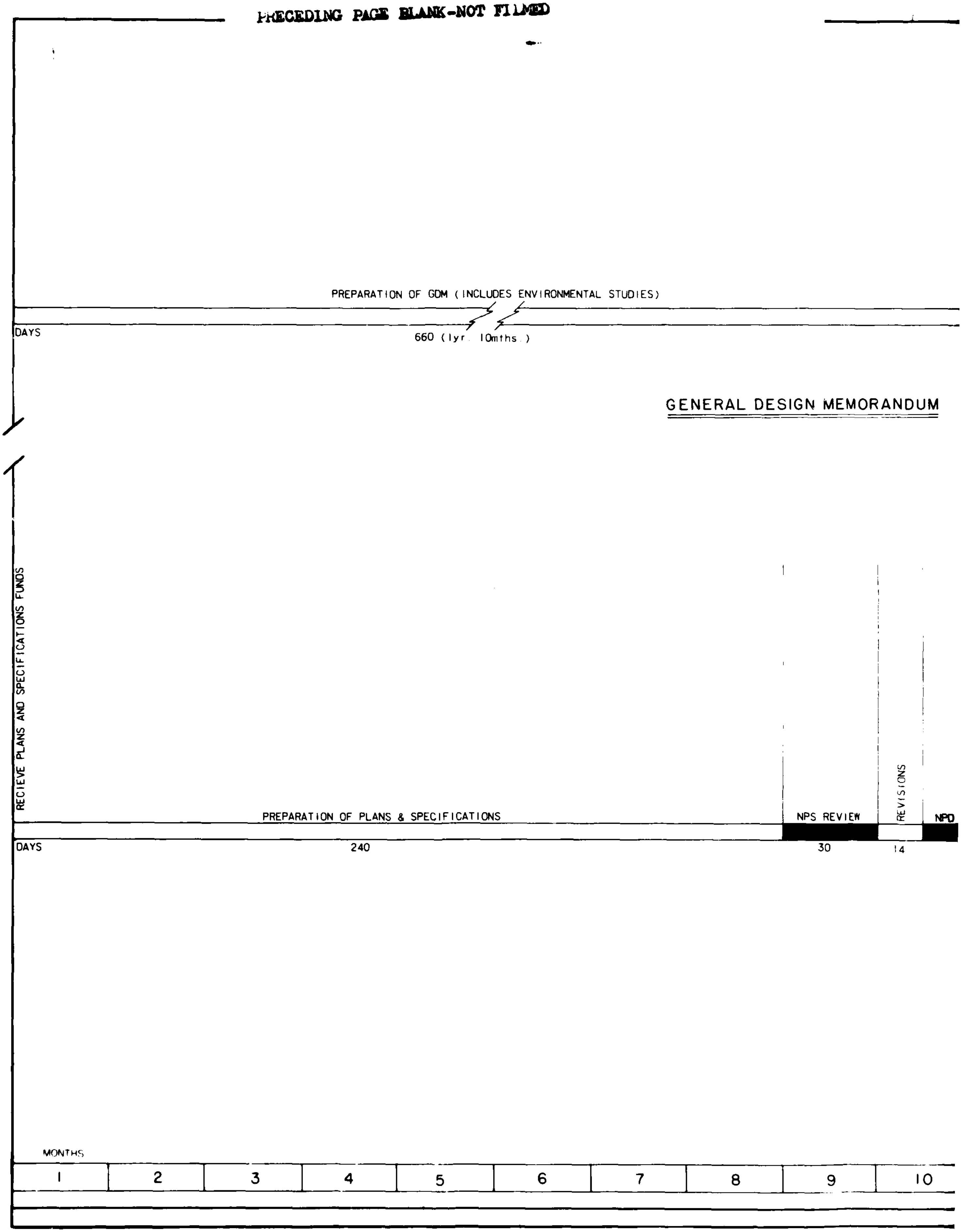
DREDGING QUANTITIES, COSTS, AND SCHEDULE

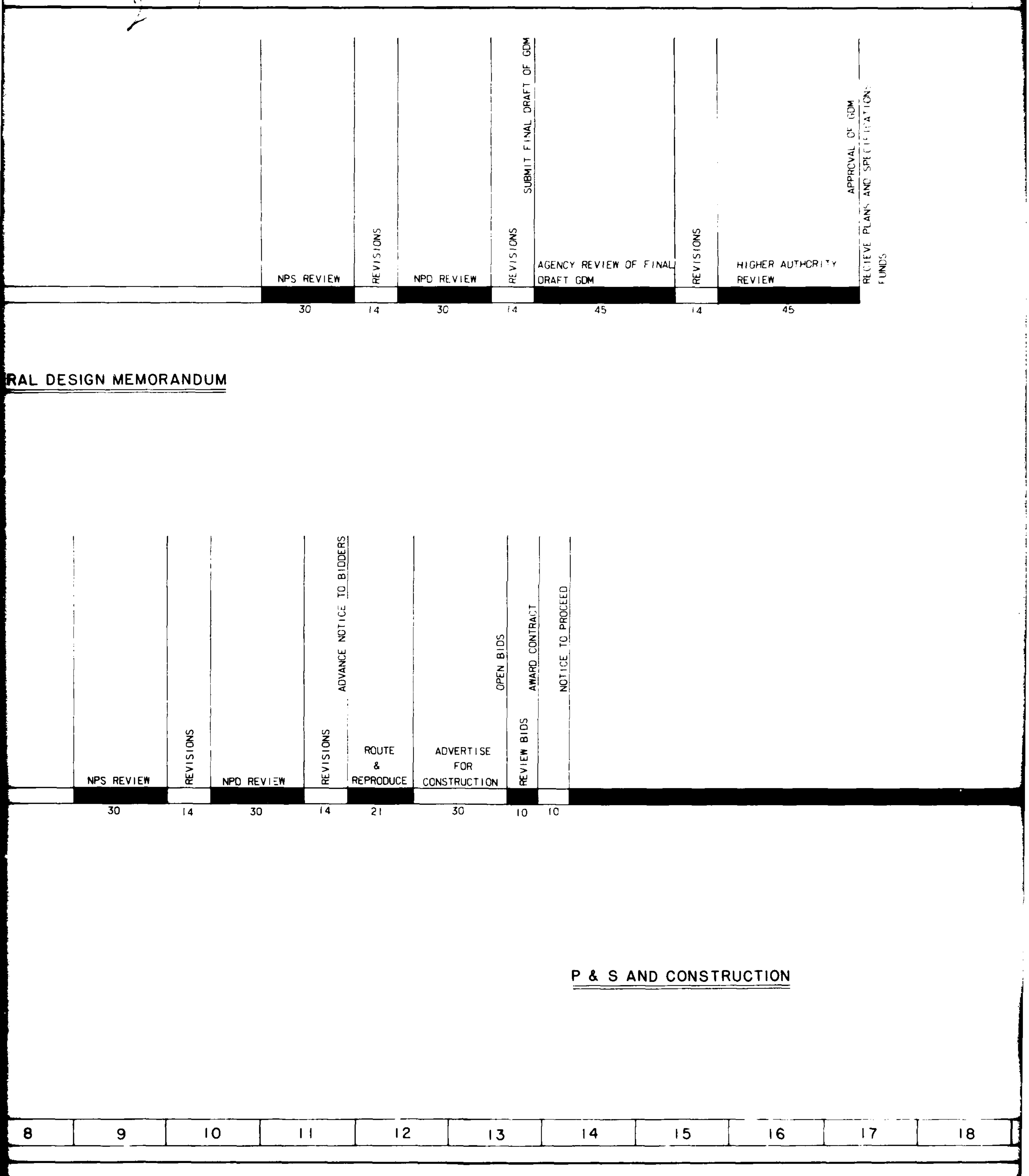
GRAYS HARBOR — WASHINGTON

SIZE	INVITATION NO.	FILE NO.	DATE	PLATE
			29 JAN 82	10

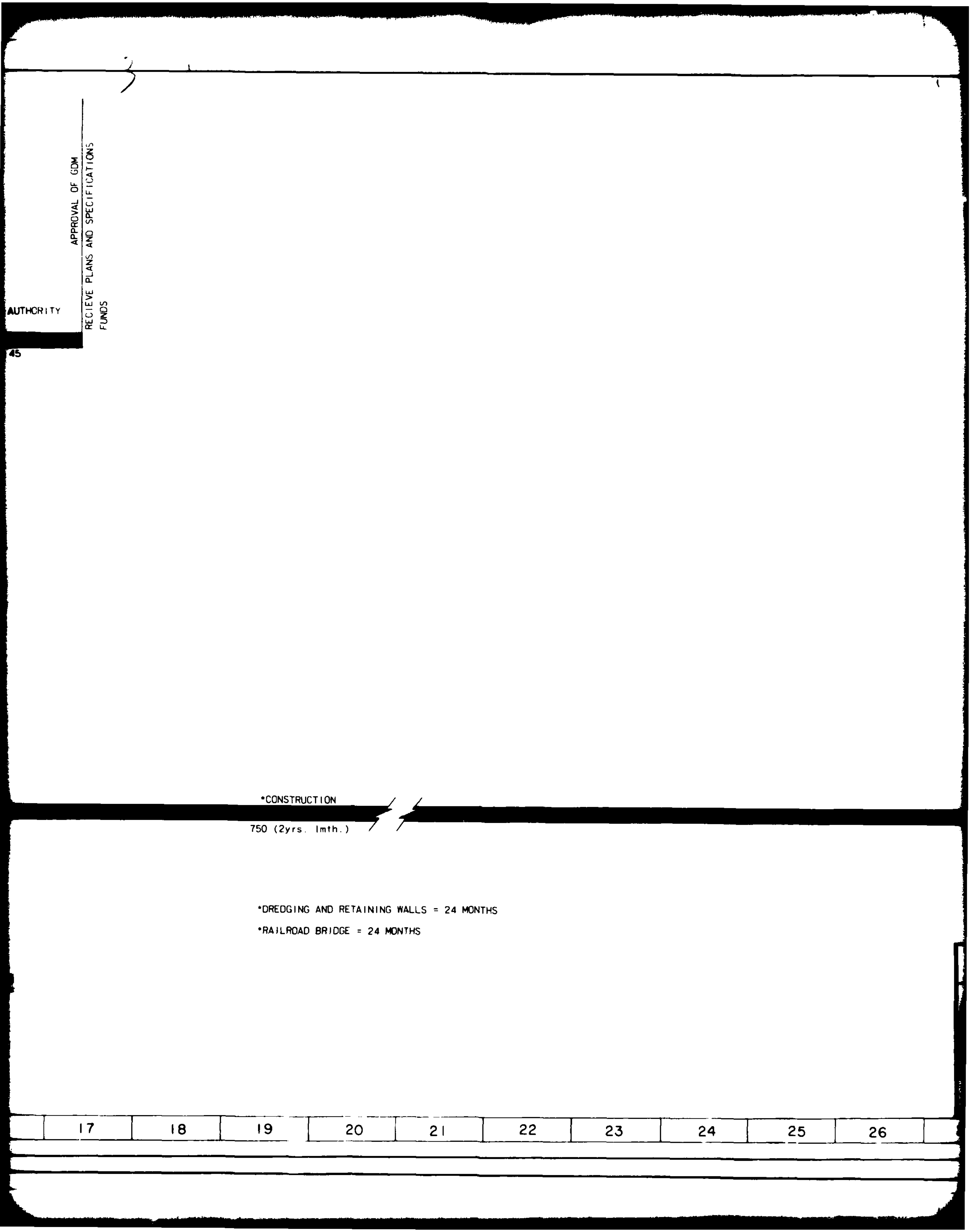
DSGN	CHK	SHEET
		2 of 2

PRECEDING PAGE BLANK-NOT FILMED





NPS REVIEW
30
REVISIONS
14
NPD REVIEW
30
REVISIONS
14
SUBMIT FINAL DRAFT OF GDM
AGENCY REVIEW OF FINAL DRAFT GDM
45
REVISIONS
14
HIGHER AUTHORITY REVIEW
45
APPROVAL OF GDM
RECIEVE PLANS AND SPECIFICATIONS FUNDS
RAL DESIGN MEMORANDUM
NPS REVIEW
30
REVISIONS
14
NPD REVIEW
30
REVISIONS
14
ADVANCE NOTICE TO BIDDERS
ROUTE & REPRODUCE
21
ADVERTISE FOR CONSTRUCTION
30
OPEN BIDS
REVIEW BIDS
10
AWARD CONTRACT
NOTICE TO PROCEED
10
P & S AND CONSTRUCTION
8
9
10
11
12
13
14
15
16
17
18


APPROVAL OF GOM
AUTHORITY
RECIEVE PLANS AND SPECIFICATIONS
FUNDS
45
*CONSTRUCTION
750 (2yrs. 1mth.)
*DREDGING AND RETAINING WALLS = 24 MONTHS
*RAILROAD BRIDGE = 24 MONTHS
17
18
19
20
21
22
23
24
25
26

U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

GRAYS HARBOR AND CHEHALIS RIVER

DESIGN AND CONSTRUCTION SCHEDULE

GRAYS HARBOR WASHINGTON

SIZE	INVITATION NO	FILE NO	DATE	PLATE
			6 JAN 82	11
DSGN		CHK	SHEET	

24	25	26	27	28	29	30

APPENDIX A

SECTION 404(b)(1) and PRELIMINARY SECTION 103 EVALUATION

NPSEN-PL-ER

Note to Reviewers of the Draft Document: The following 404(b)(1) evaluation will be finalized following completion of the ongoing biological testing of Grays Harbor sediments. The results of the biological testing will be distributed during the public review process of this document (June-July, 1982). Therefore, a final decision regarding the acceptability of the proposed dredged material for open-water disposal and compliance with the 404(b)(1) guidelines will be determined upon completion of the biological testing. At that time, a revision of this Appendix will be distributed to all recipients of this Feasibility/EIS document. Based on previous chemical testing of Grays Harbor sediments and preliminary information from the biological testing, the Corps of Engineers expects to be in compliance with the section 404(b)(1) of the Clean Water Act (CWA).

Appendix A

NPSEN-PL-ER

APPENDIX A

GRAYS HARBOR AND CHEHALIS AND HOQUIAM RIVERS, WASHINGTON
IMPROVEMENTS FOR NAVIGATION
SECTION 404(b)(1) EVALUATION AND
PRELIMINARY SECTION 103 EVALUATION

1. Introduction. The following evaluation was prepared pursuant to Section 404(b)(1) of the Clean Water Act (CWA) and Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972 in accordance with guidelines promulgated by the Environmental Protection Agency (EPA) (40 CFR Parts 220-230) for evaluation of the discharge of dredged material into waters of the United States. Pursuant to Section 404(r) of the CWA, upon submittal of this 404(b)(1) evaluation, the environmental impact statement (EIS), and approval by Congress, the Corps of Engineers proposed Grays Harbor would no longer be subject to further regulation under Section 301, 402, or 404 of the Clean Water Act. Thus, state water quality certification per Section 401 will not be required for initial construction of the project. The Grays Harbor proposed initial construction project consists of widening and deepening the existing authorized 24-mile navigation channel (plate 1) followed by a 50-year operation and maintenance (O&M) dredging program.

In addition, the Union Pacific Railroad bridge in Aberdeen will be replaced in order to increase horizontal clearance and realined to conform to the proposed channel configurations. Although the bridge construction will be covered under a nationwide permit (refer 33 CFR 323.4), a brief 404(b)(1) short form evaluation (exhibit 1) was prepared because some construction will occur in the water within a sheet pile cofferdam. Refer to paragraph EIS 2.02d(1) for detailed project description.

Dredged material disposal within the estuary (including the South Jetty and Point Chehalis sites) is regulated under Section 404 of the Clean Water Act and is addressed in section 3 below. This 404(b)(1) evaluation is preliminary and will be finalized after review of the results of the biological tests already in progress. Ocean disposal of dredged material is regulated under Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972 and is addressed in section 4 of this appendix. The preliminary Section 103 evaluation will be finalized upon completion of detailed studies during the Continuation of Planning and Engineering phase of the project.

2. Description of Proposed Discharge.

a. Need for Discharge. Under the recommended plan, sediment removal by dredging is required to widen and deepen the authorized channel and

provide safe navigation to port facilities in Grays Harbor. Deepwater estuarine sites are proposed as dredged material disposal areas for approximately 9.9 million cubic yards (c.y.) of sediment. Upland sites are costly and presently unavailable for the majority of the dredged material and, due to hazardous sea conditions, an ocean disposal site (which will receive about 7.2 million c.y. of sediment) is only available part of the year.

b. Location. Reference EIS, section 4.03b and c, and plate 3 for location of proposed estuarine in-harbor and ocean sites.

c. Description of Discharge Site. The estuarine disposal sites consist of deep scoured holes (about -50 to -60 feet below mean lower low water (MLLW)), which are maintained by prevailing ebb currents. The South Jetty site total volume capacity is approximately 2 million c.y., and the Point Chehalis total volume capacity is approximately 1.5-2 million c.y. Existing data indicates that currents have scoured approximately 2 million c.y. of sandy material out of the Point Chehalis disposal site each year since 1976. Finer materials may be expected to have a higher scour rate than sands. Refer to EIS section 4.03c for description of ocean discharge sites.

d. Method of Discharge. Bottom-dump barges or hopper dredges will be used for initial and annual maintenance disposal of dredged material.

e. Timing of Discharge. At South Jetty, sands will be discharged all year and fine materials (silts) will be discharged only during the months July through March in order to avoid impacts to crab larvae during April through June. Sands and gravels will be discharged at Point Chehalis all year round. Ocean disposal of sands, silts, and silty sands will occur at the ocean site when practicable and reasonable (April through October), depending upon sea and weather conditions. Reference plate 10 for details regarding the dredge schedule.

f. General Characteristics of Material. Dredged material from the outer portion of Grays Harbor (predominantly sands) and gravels from Cow Point will be discharged at the Point Chehalis site. The inner harbor material, which consists of sandy silts and silt, will be placed at South Jetty and at the ocean site. Outer bar sands will be discharged at the ocean site. The results of sediment grain size analysis throughout Grays Harbor by Phipps (1976) are depicted in figure A-1. AM Test (1981) also lists Grays Harbor sediment grain size analysis results. For general chemical evaluation of the dredged material, see paragraph 3.5a of the 404(b)(1) evaluation.

g. Quantity of Material. During construction, a total of 9.9 million c.y. of dredged material will be disposed of at the Point Chehalis and South Jetty sites and 7.2 million c.y. will be placed in the ocean. The annual maintenance operation calls for disposal of 1.6 million c.y. at South Jetty and Point Chehalis and .6 million c.y. at the ocean site.

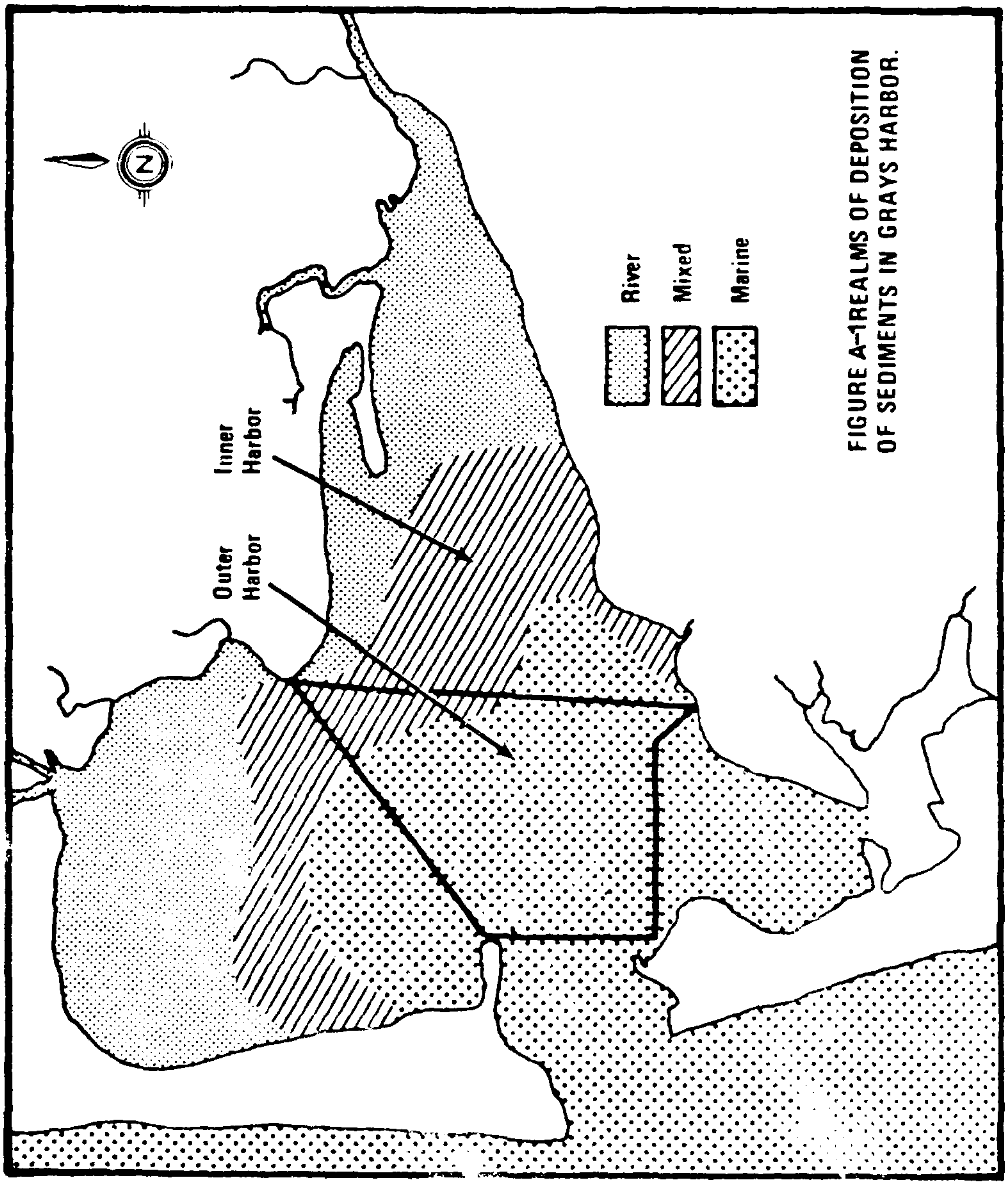


FIGURE A-1 REALMS OF DEPOSITION OF SEDIMENTS IN GRAYS HARBOR.

h. Source of Material. The dredged material to be disposed at the estuarine disposal sites will be obtained from several reaches of the navigation channel in Grays Harbor: South reach, Crossover reach, Cow Point reach, South Aberdeen reach, and Moon Island reach. This material consists of sandy silts, sands, and gravels derived originally from the ocean, the Chehalis River, and other rivers and smaller tributaries to Grays Harbor.

i. Projected Life of Disposal Site. Since currents scour approximately 2 million c.y. or more of sediments from the harbor site every year, the disposal sites are expected to be renewable for the life of the project and for the O&M program of about 50 years. The capacity of the ocean disposal site is not expected to be limited.

3. 404(b)(1) Evaluation.

3.1 Potential Impacts on Physical and Chemical Characteristics of the Aquatic Ecosystem.

a. Substrate. The material constituting the substrate at the disposal area at Point Chehalis is predominantly sand, while South Jetty substrate consists of cobble, gravel, sands, and clam shells. With the introduction of dredged material to the disposal site, the material will settle out and eventually move seaward as bedload and some of the fines may be redistributed in the estuary by currents. The South Jetty deep water site, with its existing substrate, is currently providing rockfish habitat which is utilized by commercial and recreational fishermen. Disposal of dredged material will change, by burial, the existing substrate to a habitat that will probably not be as suitable for rockfish.

b. Suspended Particulates/Turbidity. The discharge of dredged materials at the disposal sites at Point Chehalis or South Jetty will result in temporary short-term increases in suspended solids and reduced light transmission (turbidity) at the surface and near the bottom. Background ambient turbidity and dissolved oxygen (DO) levels at Point Chehalis are about 10 Jackson turbidity units (JTU) and 10 mg/l, respectively, in the winter months (Loehr and Collias, 1981). Summer levels are not available. Results of a Seattle District study with hopper dumping in 1975 (Smith et al.) in Grays Harbor determined that an average increase in turbidity was approximately 20 JTU. Light transmission values were decreased by about 10 to 15 percent. The increase in amounts of suspended solids was from 10 to 100 mg/l. No significant DO depressions were associated with the disposal of dredged material.

During hopper disposal the sediment tends to fractionate when it enters the water, the sands sinking rapidly to the bottom while some of the finer material remains in suspension much longer and moves with the water column (Smith et al., 1975).

With clamshell disposal, the silty material tends to be consolidated, will quickly sink to the bottom as a unit, and will be slowly eroded away by currents. Turbidity levels should be lower with the use of clamshell dredging and bottom-dump barges than with hopper dredge.

c. Water Quality. Studies of dredged material disposal impacts performed by the Corps of Engineers indicate that the effects on the water quality at the discharge sites will be short term and localized. DO concentrations at the Point Chehalis or South Jetty disposal sites are not expected to decrease by more than 1 mg/l (Smith et al., 1975); in fact, they may actually increase in the immediate disposal area due to entrainment of air and surface water by the dredged material.

Chemical oxygen demand (COD) analysis of sediments to be dredged do not lead one to expect a drop in DO levels. COD (percent) ranged from .17 to 7.01 in the inner harbor. The COD levels outside the channel were generally higher than those in the channel (AM Test, 1981).

Several previous studies in 1975 of Grays Harbor sediments have indicated that some of the sediment contained chemical contaminants; therefore, a detailed chemical analysis was performed on several sediment samples from Grays Harbor (for results refer to paragraph 3.4 of the 404(b)(1) Evaluation).

d. Current Patterns and Water Circulation. No changes in current patterns or water circulation of Grays Harbor are expected as a result of discharging dredged material at Point Chehalis or South Jetty.

e. Normal Water Fluctuations. The discharge of dredged material at Point Chehalis/South Jetty is not expected to have any effect on the normal water fluctuations in the Grays Harbor area.

f. Salinity Gradients. No changes in salinity levels are expected in Grays Harbor as a result of dredged material disposal at the Point Chehalis or the South Jetty disposal sites.

3.2 Potential Impacts on Biological Characteristics of the Aquatic Ecosystem.

a. Threatened and Endangered Species. Threatened and endangered species are not expected to be impacted in the Grays Harbor area by dredged material disposal at either of the deepwater disposal sites (Biological Assessment of Federally Endangered Marine Mammals, 19[illegible]).

b. Aquatic Food Web. Dredged materials will bury and may kill much of the infauna present at the disposal sites. Some recolonization by the same or similar infaunal species is expected to occur, but, due to the annual maintenance disposal of dredged material and natural wave and current action, plants and animals endemic to the area have been and continue to be limited to opportunistic species characteristic of

disturbed environments, i.e., those with high reproductive rates, short generation times, and great dispersal ability.

As dredged material is discharged into the water, some plankton will be swept from the water column by the settling sediment. The subsequent turbidity plume may also temporarily decrease primary productivity.

(1) South Jetty. The South Jetty will receive 5.6 million c.y. of dredged material, and based on the percentage of the type of material in each reach (EIS Table 2-4) 22 percent of this material is silts. The following direct impacts to the disposal area are expected:

- o Elimination of epifauna and infauna by burial and smothering.
- o Loss of good fish habitat by burial.
- o Displacement of fish by avoidance and lack of habitat.

These may be short-term impacts because data indicate that most of the material will be carried out to sea onto subtidal areas. However, the fine material maybe resuspended and recirculated within the estuary and associated sedimentation on eelgrass beds and mudflats may occur. Recolonization and recovery from initial construction is expected; however, in the long term, impacts may reoccur or persist due to disposal during the O&M program.

(2) Point Chehalis. A recent evaluation of current studies, sediment movement, model studies, drogue studies, and drifter studies within Grays Harbor estuary has been conducted. The results of these studies (see appendix D for complete discussion) indicate that the majority of material discharged at South Jetty and Point Chehalis will be carried out to the ocean by strong ebb currents. However, the drifter study indicates that some material discharged in the estuary would be recirculated and resuspended within the estuary. Associated with this sediment recycling would be increased turbidity and sedimentation in the Damon Point and North Bay vicinity which could reduce primary productivity in dense beds of eelgrass and benthic algae. The existing Point Chehalis disposal site will be moved .25 to .6 mile southwest, which, combined with the disposal of coarse (sandy) material is expected to reduce the potential for recirculation of disposal material.

Direct impacts to the new Point Chehalis site will include minimal turbidity, burial, and smothering of the resident epifauna and infauna. Recovery and recolonization from initial construction is expected; however, discharge of O&M dredged material will cause long-term impacts of this nature.

c. Wildlife. Though intertidal flats of outer Grays Harbor are used as haul-out areas and pupping grounds by harbor seals and other marine mammals (Mudd and Smith, 1976), these areas are not adjacent to the disposal sites in the estuary and no significant adverse impacts to marine mammal populations are expected.

3.3 Potential Impacts on Special Aquatic Sites.

a. Sanctuaries and Refuges. The John's River and the Oyehut Game Range sanctuaries will not be affected by the proposed discharge.

b. Wetlands, Mudflats, and Vegetated Shallows. The project does not propose discharging dredged material on wetlands, mudflats, or vegetated shallows.

3.4 Potential Effects on Human Use Characteristics.

a. Municipal and Public Water Supplies. No municipal or public water supply intakes will be affected.

b. Recreational and Commercial Fisheries. Dungeness crabs and several economically important fish use Grays Harbor as a nursery area. Some crabs and possibly some fish in the immediate vicinity are expected to be killed during the disposal process. Although commercial fishing and crabbing does not occur regularly at or adjacent to the proposed disposal sites in the outer harbor, there is some occasional commercial and sport fishing for bottom fish, rockfish, and salmon in the outer harbor near the South Jetty which is expected to be temporarily disturbed by disposal of dredged material (see paragraph 3.2b(1)).

c. Water-Related Activities. No significant impact is expected on water-related recreation other than possible temporary navigational conflicts in Grays Harbor due to transporting material to the disposal sites.

d. Esthetics. The disposal of material in Grays Harbor will have a transient effect on the esthetic value of the site. The increase in turbidity is likely to be noticed by residents and boaters during spring and summer. This impact will be temporary and minor.

e. Parks, National and Historical Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves. No effect is expected.

3.5 Evaluation and Testing of Discharge Material.

a. General Evaluation of Dredged or Fill Material. Inner Grays Harbor has a long history of water quality problems associated with low DO, low river flow, and high levels of sulfite waste liquor in combination with various discharges of contaminants (i.e., pulp and papermill outfalls, the Wishkah and Chehalis riverine inputs containing agricultural runoff, municipal wastewater treatment plant discharge, and increased shipping and port activities) (Loehr and Collias, 1981). However, the water quality in Grays Harbor has generally been improving in recent years. These sources of contaminants and the fine grain size of some Grays Harbor sediments suggest that the material to be dredged

at some locations is a potential carrier of contaminants. Existing data from chemical testing in Grays Harbor indicate that sediments to be dredged do contain contaminants in concentrations which could affect marine organisms. Sediment studies performed by Grays Harbor College in 1974 and 1975 for heavy metal and pesticide concentrations indicated the presence of both water and sediment samples with substantial amounts of toxicants (Smith et al., 1975).

Approximately 58 percent of the total volume of dredged material is to be discharged in the estuary. Table A-1 summarizes the source, quantity, and type of material to be discharged at each site.

TABLE A-1

Disposal Site	Source of Material	Quantity	Type of Material
Point Chehalis	South Reach	2,650,000	Sand
	Crossover	1,450,000	Fine sand
	Cow Point	200,000	Gravel
South Jetty	Entrance	200,000	Sand
	South Reach	750,000	Sand
	Crossover	1,450,000	Sand
	Moon Island	1,900,000	Silty sand
	South Aberdeen	1,300,000	Sandy silt
Ocean	Outer Bar	3,000,000	Sand
	Hoquiam	2,150,000	Silty sand
	Cow Point	500,000	Sandy silt
	Aberdeen	550,000	Sandy silt

The concentration of contaminants in the sediments increases with increased distance from the harbor mouth towards the Chehalis River as the grain size decreases. The eastern half of Moon Island and the South Aberdeen Reach are composed of silts and sandy silts. These and other sediments in Grays Harbor contain concentrations of some EPA priority pollutants (AM Test, 1981).

b. Evaluation of Chemical-Biological Interactive Effects.

(1) Exclusion of Material from Testing. Based on paragraph 3.5a above, it was determined that the proposed dredged material did not meet the chemical testing exclusion criteria. Samples collected in 1980 from Grays Harbor (Phase I of a two-phase chemical analysis) by Seattle District and analyzed for heavy metals, pesticides, and pulpmill waste contaminants also indicated that both the water and sediment samples contained significant amounts of a few toxicants. Several of the EPA designated priority pollutants and metals (Federal Register, 28 November 1980) were detected in concentrations which may be harmful to marine organisms.

(2) Water Column Effects. Water column effects of the proposed discharge were initially evaluated using results of elutriate tests in order to determine proposed dredged material suitability for disposal in navigable waters. Elutriate tests approximate the conditions under which contaminants associated with sediments are released into the water column. Standard elutriate tests (see AM Test, 1981 for details) were performed on samples from sites throughout the entire length of the navigation channel as indicated in figure A-2. The sediment elutriates from sites 4 and 6, located near pulpmill outfalls and municipal waste discharge (areas believed to represent areas of poor water and sediment quality in Grays Harbor) were analyzed for heavy metals, petroleum hydrocarbons, pulpmill pollutants, pesticide and PCB's and EPA's list of "priority pollutants." These parameters were also analyzed in Grays Harbor background water at sites 2 and 14. Other Phase I sites (2 and 7) only included analysis of heavy metals, PCB's, and pesticides. Contaminants found in substantial concentrations in Phase I were again measured in Phase II. The EPA and Washington Department of Ecology assisted Seattle District in determining what contaminants were present in substantial concentrations. Phase II elutriate analysis included a reduced list of heavy metals, PCB's, BHC's, and phenols (based on the results of Phase I) for sites 1, 3, 5, and 8 through 15. Samples from all sediment collected were elutriated with site 14 water (disposal site water) with the exception of samples from site 2 that were analyzed with site 2 water to simulate runoff resulting from upland disposal of dredged material should an upland disposal site be used.

Maximum values of contaminant recorded at each site for heavy metals and other organic substances in elutriates and Grays Harbor water are listed in tables A-2a and A-2b, respectively. Complete listing of data is included in AM Test, 1981.

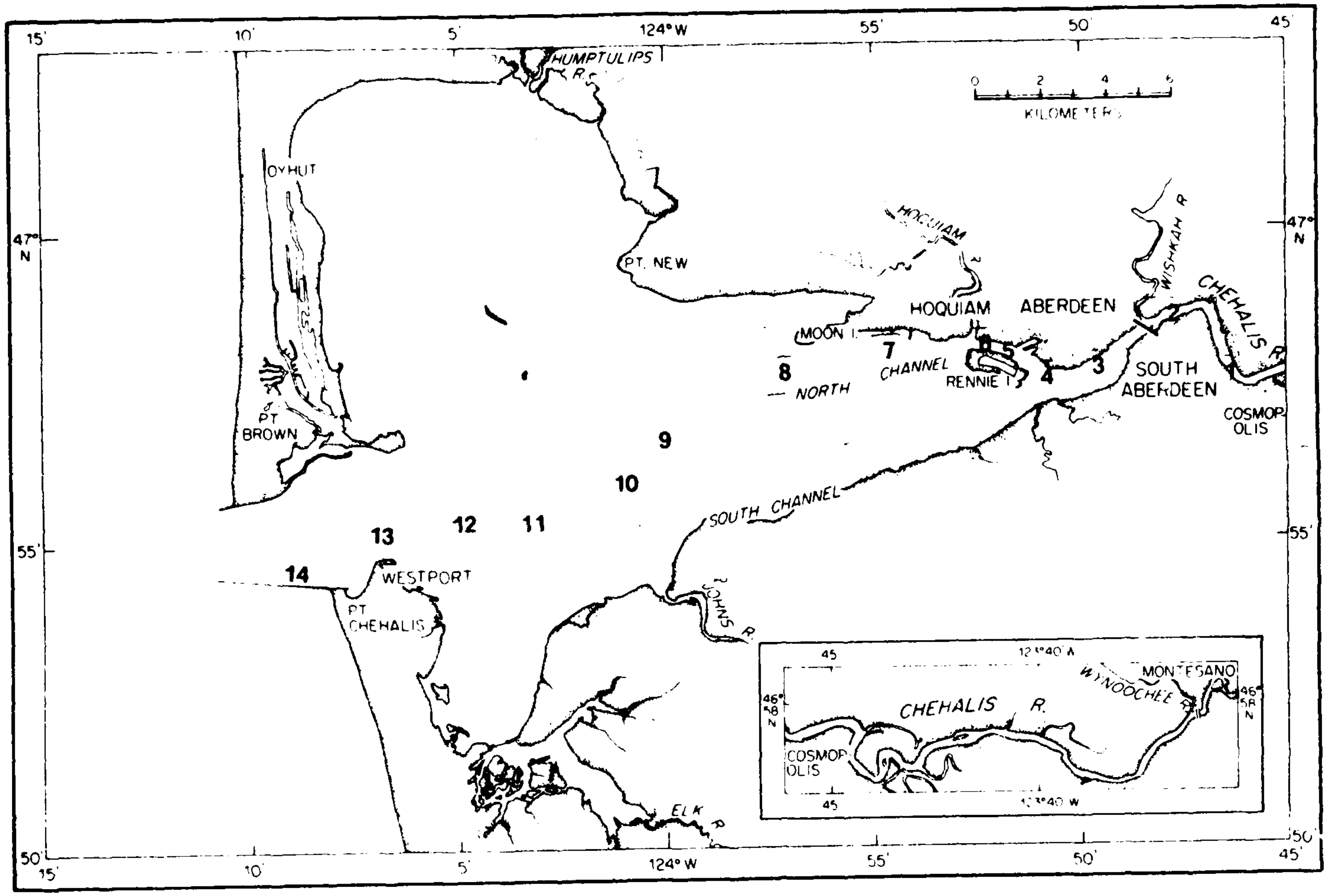


Figure A-2. Sediment sample stations in Grays Harbor, Washington

TABLE A-2a

PHASE I - MAXIMUM VALUES RECORDED AT EACH SITE
FOR SELECTED METALS AND ORGANIC SUBSTANCES IN WATER ELUTRIATE[1/]

Substances not listed were not detected in water elutriate (- = below detection limit or in concentrations equal to or below that found in background water (Table A-3), I = insufficient sample, all values shown in Table 2A-2B include background levels).

	In Channel	Adjacent to Channel	Deep Core
Site 2			
Zn (mg/l)	-	-	-
Cu (mg/l)	-	-	-
Aldrin (ppb)	-	-	-
Petroleum Hydrocarbons (mg/l)	-	-	-
PCB - 1242 (ppb)	-	.31	I
PCB - 1260 (ppb)	-	-	-
Site 4			
Zn (mg/l)	.008	.004	.012
Cu (mg/l)	-	-	-
Petroleum Hydrocarbons (mg/l)	-	-	4.0
PCB - 1260 (ppb)	1.0	.50	9.9
PCB - 1242 (ppb)	-	.42	-
Aldrin (ppb)	-	-	-
Alpha - BHC (ppb)	-	.006	-
Beta - BHC (ppb)	-	-	-
Site 6			
Zn (mg/l)	.013	.013	.010
Cu (mg/l)	-	-	-
PCB - 1260 (ppb)	-	-	-
PCB - 1242 (ppb)	-	-	-
Petroleum Hydrocarbons (mg/l)	-	-	4.0
Site 7			
Zn (mg/l)	.004	.008	.008
Cu (mg/l)	-	-	-
PCB - 1242 (ppb)	.28	.05	.14
PCB - 1260 (ppb)	3.1	.060	-

[1/] These tests are based on one-hour settling time and 1:9 (sediment/water) elutriate.

TABLE A-2b

PHASE II - MAXIMUM VALUES RECORDED AT EACH SITE FOR METALS AND ORGANIC SUBSTANCES IN WATER ELUTRIATE[1/]

Substances not listed were not detected in water elutriate (- = below detection limit or in concentrations equal to or below that found in background water (Table A-3), I = insufficient sample).

	In Channel	Adjacent to Channel	Deep Core
Site 1			
Zn (mg/1)	.04	-	-
Beta - BHC (ppb)	.580	-	-
Delta - BHC (ppb)	-	2.22	1.58
Site 3			
Zn (mg/1)	-	.08	.105
Cu (mg/1)	-	-	-
Pb (mg/1)	-	-	-
Arsenic (mg/1)	-	-	-
Alpha - BHC (ppb)	-	-	-
Beta - BHC (ppb)	-	-	.70
Delta - BHC (ppb)	-	-	-
Site 5			
Zn (mg/1)	.09	0.185	.078
Arsenic (mg/1)	.03	.03	.04
Delta - BHC (ppb)	.29	1.32	.45
Cu (mg/1)	-	-	-
Pb (mg/1)	-	-	-
Site 8			
Arsenic	.03	-	-
Delta - BHC	-	13.7	13.7

Site 9

No contaminants in concentration above that in background water.

Site 10

No contaminants in concentration above that in background water.

[1/] These tests are based on one-hour settling time and 1:9 (sediment/water) elutriate.

TABLE A-2b (con.)

	In Channel	Adjacent to Channel	Deep Core
Site 11			
No contaminants in concentration above that in background water.			
Site 12			
No contaminants in concentration above that in background water.			
Site 13			
No contaminants in concentration above that in background water.			
Site 14			
No contaminants in concentration above that in background water.			

TABLE A-3

CONCENTRATIONS OF METALS AND ORGANIC SUBSTANCES IN WATER SAMPLES[1/]

(Only those used for water elutriate are shown)

Phase I

Substance	Dredge Site (Station 2)	Reference Site (Station 14)
Zn (mg/l)	0.006	0.003
PCB - 1260 (ppb)	0.37	0.28

Phase II

Substance	Dredge Site (Station 2)	Reference Site (Station 14)
Cu (mg/l)	0.025	0.030
Zn (mg/l)	0.034	0.067

[1/] The water from these reference sites was used to prepare sediment elutriates.

Of the 140 compounds tested for, nine compounds were found in the elutriates of the Grays Harbor sediment that is proposed to be discharged at Point Chehalis and South Jetty. Not all compounds were found at each site. The results of the detailed two-phase contaminant study in Grays Harbor indicate that zinc and copper were found throughout the estuary and BHC's and PCB's were found predominantly at sites 5 and 4, respectively. The dredged material from sites 3 through 6 is proposed for disposal in the ocean due to the greater number and greater concentrations of contaminants in elutriate water samples from those sites. In Phase I, higher levels of metals and organics were found in the station 2 water than the reference site water from site 14. In Phase II, the station 2 water had lower concentrations of zinc and copper than the reference site water (see table A-3). EPA criteria (EPA, 1976, Quality Criteria for Water) were exceeded for zinc, copper, BHC, and PCB's in some samples. The criterion for zinc (.058 mg/l) was exceeded at sites 3 and 5; for copper (.004 mg/l) at sites 1, 8, and 10 through 14; for BHC (.004 ppb) at sites 1, 3, 4, 5, and 8; for PCB (.03 ppb) at sites 2, 4, and 7 (see AM Test, 1981 for details on results of chemical studies). The effects of these contaminants are being evaluated during the ongoing biological tests. Preliminary indications of test results suggest that adverse contaminant effects will not occur due to open-water disposal of the dredged material (see exhibit 2).

(3) Effects on Benthos. Chemicals in the dredged material may be toxic to benthic organisms and may accumulate in the tissues of organisms existing in the vicinity of the disposal site. Bioassay and bioaccumulation tests which are presently being conducted address the concerns for long-term impacts on benthic organisms due to the uptake of sediment-associated contaminants (exhibit 2). This evaluation is designed to answer questions regarding the fate and effects of contaminants contained in the dredged material. The results of the biological tests will be incorporated into this report upon completion of the studies (anticipated for June 1982).

c. Comparison of Excavation and Discharge Sites.

(1) Total Sediment Chemical Analysis. Physical and chemical analyses of sediments in Grays Harbor were performed in 1981 at all Grays Harbor sample sites. A subsample of sediment from each sampling station was analyzed for COD, volatile solids, and PCB's. The COD percentages ranged from 0.17 to 7.01, with four samples, at sites 3, 5, and 7, above 5.0 (see table 3, AM Test, 1981). These COD levels are not considered to be very high or likely to cause reduction of DO levels. The samples taken adjacent to the channel tended to have higher values than those taken in the channel. The highest average percentage values for COD were 3.65 at site 3 and 3.48 at site 5. Inner harbor samples generally had higher COD values than the outer harbor samples (AM Test, 1981).

Volatile solid percentages ranged from .43 to 7.61 with three samples, at sites 3, 8, and 9, above 5.0 (table 3, AM Test, 1981). These volatile solids values are not excessive and are not expected to cause a

reduction of DO levels at the disposal sites. The volatile solid values of the in-channel samples generally were lower than the samples taken adjacent to the channel. The average volatile solid percentage was highest at site 6 with a value of 3.4. Concentrations of PCB's detected in the sediment ranged from .017 parts per million (p.p.m.) to 0.39 p.p.m. (table 4, AM Test, 1981). The greatest concentration occurred at the in-channel sample at site 3. The majority of the sediment samples collected throughout Grays Harbor had PCB concentration below the detection limit of .001 p.p.b. The results of the chemical evaluation indicate that disposal of sediments dredged from the inner harbor would introduce finer grained material with contaminant levels generally higher than those found at the coarse grained disposal sites, South Jetty and Point Chehalis. The potential for altering the structure of benthic communities at the South Jetty and Point Chehalis disposal sites is low because the dilution and dispersal potential of discharged sediments at the South Jetty and Point Chehalis sites is quite large.

d. Physical Tests and Evaluation. An analysis of sediment grain size using sieve analysis was performed at all sample sites throughout Grays Harbor (figure A-2). Changes in sediment grain size at the disposal site caused by dredged material disposal would probably result in significant alterations of the benthic biological community. The average amount of fine material (smaller than 0.106 mm in diameter) measured as a percentage of the total weight of the sample was high in most samples and ranged from 13 to 89 percent. The highest values were generally recorded for samples taken in the middle of the channel. The sediment below 20 cm at the sites sampled also contained a large proportion of fine material (ranging from 40 to 77 percent). Inner harbor sites generally contained sediment of finer grain size than the outer harbor sites. These results indicate that the sediment grain size at the disposal site may become finer after disposal of dredged material. However, this will be a temporary change and the finer sediments will quickly be scoured from the disposal sites. Temporary alteration of the benthic community at the disposal site caused by changes in sediment grain size can be expected.

Winter and summer drifter studies were performed at many sites in the outer Grays Harbor estuary and in the ocean off the coast of Grays Harbor to provide field data on sediment and water circulation patterns. This study was set up to assist in determining the fate of sediments discharged near the mouth of Grays Harbor. In winter and summer, 1,000 bottom and 1,000 surface "Kahlsico" drifters were released. Of the 2,000 drifters released, approximately 32 percent of the winter bottom drifters, 21 percent of winter surface drifters, 14 percent of summer bottom drifters and 18 percent of summer surface drifters were recovered. The results of the drifter study indicate a strong northward component exists for surface and bottom waters during winter and a weak southward component exists in summer in nearshore ocean waters. In general, the study confirms the expected circulation patterns in Grays Harbor and of the shallow ocean waters off the coast. Winter bottom drifters released

in the estuary north during February 1981 indicated a high return into the Damon Spit and North Bay areas of the estuary. Very few surface and bottom ocean drifters released at the proposed South Jetty site returned to the harbor. As a result of these findings, and other model studies, the existing Point Chehalis disposal site will be moved approximately 1/4 mile southwest. Due to the low percentage of drifters recovered, it is difficult to draw conclusions with a high degree of accuracy.

3.6 Factual Determinations.

a. Physical Determinations. The proposed discharge will not result in significant adverse impacts to water circulation or fluctuation or salinity. Significant, but temporary, impacts to turbidity and suspended solids will occur. Long-term intermittent impacts to sediment grain size, especially at the South Jetty site, are expected due to the initial construction and the proposed 50-year O&M program.

b. Contaminant Determination. The disposal of dredged material will introduce zinc, copper, and BHC's and PCB's from the inner harbor sediments to the South Jetty and Point Chehalis sites in concentrations higher, in some cases, than the existing values in these outer harbor disposal sites (tables A-2a and A-2b). Without considering initial water column dilution or mixing these contaminants also exceed the EPA criteria. The chemical results indicate there is a potential for slightly increasing the concentration of contaminants at South Jetty and Point Chehalis. This material has the potential for both alteration of the benthic communities at the disposal site and for altering the movements of crabs and fish into and out of the estuary. Complete results of the ongoing biological tests are needed before a final determination of impacts can be made.

c. Aquatic Ecosystem and Organism Determination

(1) Point Chehalis. With the disposal of sands and gravels at Point Chehalis, increased turbidity is expected during disposal. Benthic infauna will be buried. Recolonization by existing organisms is expected to occur because the disposal material is similar to the disposal site substrate. Elutriate analysis indicates that the levels of contaminants could increase in benthic organisms in the region. Ongoing biological tests will address this issue.

The long-term cumulative effects will generally be confined to the disposal site. With the yearly disposal of maintenance dredged material, the functioning of the immediate aquatic ecosystem will be altered. However, adverse effects to the integrity of the ecosystem of Grays Harbor will not occur.

(2) South Jetty. Disposal of fine-grained dredged material will result in temporary increases in turbidity, possible reduction of phytoplankton productivity, and short-term increases in the level of

certain chemical contaminants in the water column. Benthic organisms will be buried but recolonization by these organisms will occur. The disposal of contaminated sediment at the mouth of the harbor may have an adverse impact on the movement of crabs into the estuary during construction. Based on existing data, the disposed sediments are expected to be carried to the ocean by the predominant ebb currents at the site (Schuldt, 1981), settling out subtidally. Therefore, impacts are expected to be temporary.

3.7 Proposed and Alternative Actions to Minimize Adverse Effects. Measures to minimize environmental impacts caused by dredged material disposal at South Jetty and Point Chehalis are summarized below.

a. Location of Discharge. The new Point Chehalis site has been selected as a disposal site at which the substrate is composed of material similar to that being discharged, therefore discharging sand on sand.

b. Material to be Discharged.

o Discharging mostly sands and gravels at Point Chehalis to minimize potential recirculation of contaminants and fine grained material.

o Discharging least contaminated silty sediments at South Jetty and the most contaminated sediment in the ocean.

c. Technology Related Action. Bathymetric readings will be taken at disposal site so as not to exceed capacity of scoured area.

d. Actions Affecting Plant and Animal Populations. Avoid discharging silts during April, May, and June to avoid impacts to crab larvae.

e. Actions Affecting Human Use. Actions to minimize adverse effects on human use are described below.

(1) Confining disposal to sites which are not valuable aquatic sites such as confined upland and deep oceanic areas.

(2) Timing discharge to avoid peak seasons of Dungeness crab abundance.

(3) Selecting a site which minimizes the disturbance of esthetic features of an aquatic site.

Paragraph 3.7e(1) above, which is not considered practicable in this case, is discussed in paragraph 3.9a of the 404. See paragraph 3.7d for actions taken per paragraph 3.7e(2). The estuarine disposal sites do not warrant further esthetic consideration due to their low visibility and the temporary minor nature of the impact.

3.8 Analysis of Practicable Alternatives.

Identification and Evaluation of Practicable Alternatives (see table EIS 2-5). The dredged material disposal plan presented in the EIS resulted from a compromise between alternatives consisting of all in-harbor open water disposal (least costly) and all ocean disposal (most costly). The alternative disposal site plans are evaluated with respect to environmental impacts in the accompanying EIS (section 2.03). There are no practicable alternatives that would have less impact on the aquatic ecosystem than those sites proposed.

3.9 Review of Conditions for Compliance.

a. Availability of Practicable Alternatives. Per section 3.8a of this 404(b)(1) evaluation, the proposed disposal sites are Point Chehalis, South Jetty, and the ocean (within an 8-mile radius of the mouth of Grays Harbor). Ocean disposal is less environmentally damaging but is not a practicable alternative to the proposed plan for discharge of dredged material. Discharging a larger percentage of dredged material in the ocean (both initial construction and yearly maintenance material) would mitigate adverse impacts; however, the cost savings is greater using the estuary. Confined sites are available for dredged material disposal, although the cost is great and environmental impacts of filling wetlands are unacceptable. However, an alternative upland site is proposed for dredged sediments if biological testing determines that some sediment is unacceptable for open-water disposal. Although Point Chehalis and South Jetty are not the least environmentally damaging alternative, they remain as the only practicable alternative.

b. Compliance with Pertinent Legislation. It is expected the proposed discharge:

o will not jeopardize the continued existence of species listed as endangered or threatened,

o will not significantly affect esthetic values,

o will not jeopardize any marine sanctuary,

o is not expected to jeopardize human health or welfare. However, the redistribution and bioaccumulation of toxics from dredged material in fish and shellfish may occur. This is currently being examined in biological testing, and

o is not expected to contribute pollutants that will significantly affect life stages of aquatic life or other wildlife dependent upon aquatic ecosystems. This is being investigated during biological testing.

However, state water quality standards under Section 307 of the Clean Water Act may temporarily be violated within the confines of the disposal area during summer months.

c. Steps to Minimize Potential Adverse Impacts on the Aquatic Ecosystem. All appropriate and practicable steps to minimize potential adverse impacts of the discharge on the aquatic ecosystem (see section 9) have been included in the proposed discharge plan.

3.10 Findings. This evaluation is preliminary and will be finalized after review of the results of the biological tests already in progress. Presently, the dredged material discharge fails to comply with the requirements of the 404(b)(1) guidelines due to lack of sufficient information. Data on the toxicity of sediments to be discharged and the accumulation by biota of discharged toxicants are needed before a final determination on compliance can be made (reference exhibit 2 of this appendix). Sufficient information for a final determination on compliance will be available in June, 1982 and will be distributed to all recipients of this draft Feasibility Report and environmental impact statement.

4. Preliminary Section 103 Evaluation.

4.1 Environmental Impacts of the Proposed Ocean Discharge.

a. Prohibited Materials. The dredged material proposed for disposal in the ocean near Grays Harbor does not contain high levels of radioactive waste; materials produced or used for radiological, chemical, or biological warfare; or persistent inert materials which may float or remain in suspension in the ocean in such a manner that they may interfere materially with fishing, navigation, or other legitimate uses of the ocean.

b. Need for Dredged Material Testing. The dredged material to be derived from the Grays Harbor project is known to contain measurable quantities of environmental contaminants. Therefore, the material does not meet the criteria (40 CFR Part 227.13(b)(1-3)) that would exclude it from further testing in order to determine its acceptability for disposal in the ocean.

c. Constituents Prohibited as Other Than Trace Contaminants.

(1) Liquid Phase Chemical Testing. Chemical testing of the liquid phase of the proposed dredged material was recently conducted by the Corps of Engineers (AM Test, 1981). Heavy metals, pesticides, PCB's, and pulpmill effluent contaminants were found in the sediment elutriate. A summary of the results and their relation to existing marine water quality criteria promulgated by EPA is contained in paragraph 3.6b above. The presence of compounds known to be toxic and for which EPA criteria does not exist dictates the need for biological

testing of the liquid phase to determine its acceptability for disposal in the ocean.

(2) Biological Testing of Dredged Material. Bioassay and bioaccumulation tests on the combined liquid/suspended phase and solid phase of the Grays Harbor dredged material are ongoing. These tests will determine acceptability of the dredged material for disposal in the ocean by evaluating its potential for causing significant adverse effects due to toxicity (mortality) or contaminant bioaccumulation in marine organisms. Results will be summarized in exhibit 2.

(3) Carcinogens, Mutagens, and Teratogens. The proposed Grays Harbor dredged material is known to contain compounds that are considered to be carcinogenic by responsible scientific opinion. However, it is not presently known whether the concentrations of these compounds released during dredging is sufficient to produce biological effects. Therefore, the extent and significance of their distribution and effect will be evaluated during the Continuation of Planning and Engineering (CP&E) phase of the project. If carcinogenic, mutagenic, or teratogenic effects are observed or expected, the material containing these compounds will be discharged into a confined, upland disposal area.

4.2 Need for Ocean Dumping.

a. Need for the Project. Need for, and objectives of, the project are described in section 1.02 of the EIS.

b. Alternatives to Ocean Disposal. Alternative disposal areas are evaluated in section 2.03c of the EIS. Alternative disposal areas that do not involve the ocean and that have less adverse environmental effects do not exist.

4.3 Impact to Recreational, Economic, and Esthetic Values. Preliminary impact information pertaining to recreational and economic values is briefly discussed in paragraphs 4.03d(1), (2) and (3) of the EIS. Impacts to esthetics are expected to be limited to temporary increases in turbidity of surface waters at the disposal site, visible to sports and commercial fishermen. The extent of these impacts is related to the proximity to shore of the selected disposal site (in general, the closer sites have higher risk, more public concern, and greater impact potential). Disposal site locations and selection are discussed below.

4.4 Impact on Other Uses of the Ocean. Preliminary impact information pertaining to fisheries, navigation, and shoreline uses of the ocean are generally discussed in section 4 of the EIS. The proximity of the disposal site to shore is the main factor that will determine the extent of these impacts. Disposal is not expected to impact potential exploitation of nonliving resources (oil, minerals, etc.) or areas unique to scientific research and study.

4.5 Selection and Management of the Proposed Ocean Disposal Site(s).

a. Site Selection and Designation. An approved ocean disposal site near Grays Harbor does not presently exist. Therefore, a new site will need to be selected from among the potential sites identified to date. The required site selection and designation surveys will be performed during the CP&E phase. The surveys will include measurement of physical, chemical, and biological characteristics of the sites, with emphasis on benthic parameters (due to higher potential for adverse effects on the bottom). Site selection will be based on cost of using a site, minimization of impacts to ocean resources, and avoidance of impacts to resource user activities Site designation will involve preparation of an EIS supplement in cooperation with EPA (to be done during CP&E).

b. Site Monitoring and Management. Site designation surveys will provide baseline information that will serve as the basis for monitoring and management of site use. Monitoring of site use will be conducted every 6 months after initiation of disposal in the ocean and during construction. Information gathered during monitoring surveys will be used to evaluate disposal impacts and will allow EPA and the Corps of Engineers to make informed site management decisions regarding continued site use and/or needed modification of such use.

EXHIBIT 1

SECTION 404(b)(1) SHORT-FORM EVALUATION
FOR THE ABERDEEN BRIDGE CONSTRUCTION,
GRAYS HARBOR NAVIGATION CHANNEL IMPROVEMENT PROJECT

During construction of the new Union Pacific Railroad, some filling with concrete will occur in the water within a sheet pile cofferdam. The following is a short form evaluation of this 404 action.

	Preliminary Yes	Preliminary No
1. Review of Compliance (Section 230.10(a)-(d).		
A review of the permit application indicates that:		
a. the discharge represents the least environmentally damaging practicable alternative, and if in a special aquatic site, the activity associated with the discharge must have direct access or proximity to, or be located in, the aquatic ecosystem to fulfill its basic purpose;	X	
b. the activity does not appear to: (1) violate applicable state water quality standards or effluent standards prohibited under Section 307 of the CWA; (2) jeopardize the existence of federally listed endangered or threatened species or their habitat: and (3) violate requirements of any federally designated marine sanctuary;	X	
c. the activity will not cause or contribute to significant degradation of waters of the United States, including adverse effects on human health; life stages of organisms dependent on the aquatic ecosystem; ecosystem diversity, productivity, and stability; and recreational, esthetic, and economic values; and	X	

	Preliminary Yes	Preliminary No
d. all appropriate and practicable steps have been taken to minimize potential adverse impacts of the discharge on the aquatic ecosystem.	X	

2. Technical Evaluation Factors (Subparts C-F).	Not Significant	Significant
a. Physical and Chemical Characteristics of the Aquatic Ecosystem (Subpart C).		
(1) Substrate impacts.	X	
(2) Suspended particulates/turbidity impacts.	X	
(3) Water column impacts.	X	
(4) Alteration of current patterns and water circulation.	X	
(5) Alteration of normal water fluctuations/hydroperiod.	X	
(6) Alteration of salinity gradients.	X	
b. Biological Characteristics of the Aquatic Ecosystem (Subpart D).		
(1) Effect on threatened/endangered species and their habitat.	X	
(2) Effect on the aquatic food web.	X	
(3) Effect on other wildlife (mammals, birds, reptiles, and amphibians).	X	
c. Special Aquatic Sites (Subpart E).		
(1) Sanctuaries and refuges.	X	
(2) Wetlands.	X	
(3) Mudflats.	X	
(4) Vegetated shallows.	X	
d. Human Use Characteristics (Subpart F).		
(1) Effects on municipal and private water supplies.	X	
(2) Recreational and commercial fisheries impacts.	X	
(3) Effects on water-related recreation.	X	

	Not Significant	Significant
(4) Esthetic impacts.	X	
(5) Effects on parks, national and historical monuments, national seashores, wilderness areas, research sites, and similar preserves.	X	

3. Evaluation of Dredged or Fill Material (Subpart G).

   a. The following information has been considered in evaluating the biological availability of possible contaminants in fill material.

      (1) Physical characteristics.
      (2) Hydrography in relation to known or anticipated sources of contaminants.

   b. An evaluation of the appropriate information in 3a above indicates that there is reason to believe the proposed fill material is not a carrier of contaminants and not likely to be a constraint. The material meets the testing exclusion criteria. YES X NO __

4. Disposal Site Delineation (Section 230.11(f)).

   a. The following factors, as appropriate, have been considered in evaluating the disposal site.

      (1) Depth of water at disposal site.
      (2) Current velocity, direction, and variability at disposal site.
      (3) Degree of turbulence.
      (4) Water column stratification.
      (5) Fill material characteristics (constituents, amount, and type of material, settling velocities).
      (6) Other factors affecting rates and patterns of mixing (specify).

   b. An evaluation of the appropriate factors in 4a above indicates that the disposal site and/or size of mixing zone are acceptable YES X NO __

5. Actions to Minimize Adverse Effects (Subpart H).

All appropriate and practicable steps have been taken, through application of recommendation of Section 230.70-230.77, to ensure minimal adverse effects of the proposed discharge. List actions taken.

a. The existing plan calls for the use of a cofferdam which will isolate the fill material from the existing body of water and should minimize and/or eliminate any turbidity problems and aquatic ecosystem alterations.

6. Factual Determination (Section 230.11).

A review of appropriate information as identified in items 2-5 above indicates that there is minimal potential for short- or long-term environmental effects of the proposed discharge as related to:

a.	physical substrate at the disposal site (review sections 2a, 3, 4, and 5);	YES X	NO ___
b.	water circulation, fluctuation, and salinity (review sections 2a, 3, 4, and 5);	YES X	NO ___
c.	suspended particulates/turbidity (review sections 2a, 3, 4, and 5);	YES X	NO ___
d.	contaminant availability (review sections 2a, 3, and 4);	YES X	NO ___
e.	aquatic ecosystem structure and function (review sections 2b and c, 3, and 5);	YES X	NO ___
f.	disposal site (review sections 2, 4, and 5);	YES X	NO ___
g.	cumulative impact on the aquatic ecosystem; and	YES X	NO ___
h.	secondary impacts on the aquatic ecosystem.	YES X	NO ___

7. Evaluation Responsibility.

a. This evaluation was prepared by: Peggy Watt.
Position: Biologist, Environmental Resources Section.
Date: 30 September 1981.

8. Findings.

The proposed disposal site for discharge of dredged or fill material complies with the Section 404(b)(1) guidelines with the inclusion of the following conditions:

a. Proposed work must include use of a cofferdam for all fill material used during construction of bridge.

NPSEN-PL-ER

EXHIBIT 2

PRELIMINARY EVALUATION OF BIOLOGICAL TESTING
OF DREDGED MATERIAL
GRAYS HARBOR AND CHEHALIS AND HOQUIAM RIVERS, WASHINGTON,
IMPROVEMENTS FOR NAVIGATION

1. Introduction. The biological testing of dredged material for the Grays Harbor Improvements for Navigation was initially proposed and outlined during the 19 9 interagency scoping task force for the Grays Harbor project. The basic intent of the program is to meet the testing requirements of Section 404(b)(1) of the Clean Water Act and Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972 and to implement Environmental Protection Agency (EPA) regulations (40 CFR 220-230). The testing was determined to be necessary based on results of previous physical and chemical testing of the proposed dredged material. Biological testing results will be used to determine the acceptability of the dredged material for disposal in open water.

Fisheries Research Institute (FRI) of the University of Washington was contracted by the Seattle District, Corps of Engineers to conduct the Grays Harbor tests. FRI initially developed a detailed testing protocol based on the scoping task force's outline for testing, and based on input from Government and private biological laboratories on the west coast, in addition to their own experience. FRI's protocol was approved by EPA and Seattle District, and was coordinated with all concerned resource agencies prior to implementation. FRI then proceeded to construct a mobile laboratory, install it at Westport, Washington, and initiate the testing program. Since initiation of the testing, several changes in the protocol became necessary due to project constraints (funding, schedule) and biological conditions (organism availability, source water characteristics). The testing program is described below.

2. Methods.

a. Sediment Stations. Three sites in the inner estuary were selected for collection of sediments to be used in the biological tests. The locations of these sites, described below, are considered to be representative of areas in the estuary containing the highest concentrations of sediment contaminants.

(1). Station "X" is located immediately south of the navigation channel near the mouth of the Hoquiam River and the west end of Rennie Island in approximately 10 feet of water (at mean lower low water, (MLLW)).

(2). Station "O" is located immediately south of the navigation channel near the west end of Terminal 4 at Cow Point in approximately 9 feet of water (MLLW).

(3). Station "40" is located immediately south of the navigation channel near the east end of the Moon Island airstrip in approximately 12 feet of water (MLLW).

Control sediment was collected from the mouth of the Elk River, South Bay, Grays Harbor. Ambient seawater from the mouth of the estuary near the Point Chehalis groins is being used in all biological tests.

b. Combined Liquid-Suspended Phase Tests. The combined liquid-suspended phase represents the water column plume resulting during dredged material disposal. Settleable solids have been removed from this phase.

(1). Mortality Test. Toxicity effects of the liquid-suspended phase of dredged material were evaluated by use of 96-hour, static bioassays on the first stage zoea of the Dungeness crab (*Cancer magister*). In all tests (except for a few "minimum handling" tests), zoea were observed every 24 hours. "Active" zoea were those swimming freely in the test solutions; "inactive" zoea were resting on the bottom of the test container but would swim when prodded; "moribund" zoea were on the container bottom, did not swim when prodded but had a visible heart beat; and "dead" zoea lacked a heart beat and did not swim when prodded. For purposes of summarizing test results, "active" and "inactive" zoea were classified as alive while "moribund" and "dead" zoea were classified as dead.

(2). Chemical Uptake. Bioaccumulation effects of the liquid-suspended phase were evaluated by use of 10-day, continuous-flow tests with 0+ age chum salmon (*Oncorhyncus keta*). The continuous exposure of the salmon to a suspended sediment plume was obtained through a slurry chamber/baffle chamber/serial diluter apparatus designed and constructed by FRI. The salmon are presently undergoing chemical analysis to determine if contaminants of concern were bioaccumulated (see paragraph 2d below).

c. Solid Phase Tests. The solid phase of the dredged material represents the mound of dredged material found at the bottom of a disposal site. Settleable solids are included in this phase.

(1). Mortality Test. Toxicity effects of solid phase are being evaluated by use of 96-hour, flow-through bioassays with the amphipod species *Grandifoxus grandis*.

(2). Chemical Uptake. Bioaccumulation of contaminants of concern by benthic organisms is being evaluated by use of 30-day, flow-through tests with a clam (*Macoma nasuta*, bent-nose clam), a polychaete (*Abarenicola pacifica*, lugworm) and a flatfish (*Parophrys vetulus*, English sole). Contaminants to be measured in the tissues of these organisms are listed in paragraph 2d below.

d. Contaminants of Concern. The contaminants to be measured in the tissues of bioaccumulation test organisms were identified during chemical testing of dredged material (AM Test, 1981, see EIS bibliography). They include:

(1). PCB 1242 and 1260

(2). Aldrin

(3). BHC (alpha, beta, gamma, delta)

(4). Heavy metals (Cu, Zn, Cd)

(5). Phthalate esters (diethyl, dimethyl, di-N-butyl and bis (2-ethylhexyl) phthalates)

(6). Naphthalene

3. Results.

a. Status of Tests. The crab zoea tests have been completed. The salmon bioaccumulation tests have been completed and the tissues are undergoing chemical analysis. The other tests are in progress. Completion of the tests is scheduled for June, 1982, at which time an update to this report will be provided to all recipients of the feasibility report and draft environmental impact statement for the Grays Harbor project. A complete contract report on FRI's work is scheduled for distribution in September, 1982.

b. Crab Zoea Tests. Crab zoea test results are summarized in Tables 1-4, each table representing a separate test series. The first bioassay (Table 1) was a range finding test. The second bioassay (Table 2) evaluated the effect of filtration on the toxicity of the test solution. The third bioassay (Table 3) was designed to evaluate the effects of handling and starvation on test results and to confirm an indication of potential toxicity at station "X". The last bioassay (Table 4) was performed to again look at tentative toxicity of station "X" and to obtain some information on variability between sediment samples taken from the same station.

Although detailed analysis of this information will not be conducted until all biological tests have been completed, preliminary indications of these data suggest that chemical toxicity effects to crab zoea would not occur during open-water disposal of Grays Harbor dredged material once mixing and dilution within the water column of the disposal site takes place.

TABLE 1

Ninety-six hour responses of Dungeness crab zoea to filtered sediment elutriate from four Grays Harbor sites.

	Alive	Dead
Control seawater	23	2
Control seawater	19	6
Station X, 1:5[1/]	10	15
X, 1:50	21	4
X, 1:500	20	5
Station 0, 1:5	22	3
0, 1:50	18	7
0, 1:500[2/]	23	3
Station 40, 1:5	22	3
40, 1:50	22	3
40, 1:500	20	5
Control sediment, 1:5	22	3
" " 1:50	22	3
" " 1:500	21	4

[1/]Sediment to water dilutions (by volume) of 1 part sediment to 5, 50 and 500 parts water were used.

[2/]Note miscount where n = 26 rather than n = 25.

TABLE 2

Effect of filtration on the 96-hour responses of Dungeness crab zoea to sediment elutriates from four Grays Harbor sites.

	Alive	Dead
Seawater control fil[1]	18	7
Seawater control fil	15	10
Station X, 1:5, fil	7	18
X, 1:5, unfil[1]	1	24
X, 1.50, fil	16	9
X, 1:50, unfil	23	2
Station O, 1:5, fil	18	7
O, 1:5, unfil	22	3
O, 1:50, fil	15	10
O, 1:50, unfil	16	9
Station 40, 1:5, fil[2]	18	9
40, 1:5, unfil	22	3
40, 1:50, fil	14	11
40, 1:50, unfil	19	6
Control sediment, 1:5, fil	13	12
" " 1:5, unfil	19	6
" " 1:50, fil	11	14
" " 1:50, unfil	21	4

[1]fil = filtered; unfil = unfiltered

[2]Note miscount where n = 27 rather n = 25.

TABLE 3

Effect of starvation on the 96-hour response of Dungeness crab zoea to filtered sediment elutriates from four Grays Harbor sites.

	Alive	Dead
Control seawater fed a.[1/]	23	2
" " " b.	25	0
" " " c.	22	3
Control seawater unfed a.	25	0
" " " b.	24	1
" " " c.	24	1
Station X. 1:5, fed a.	22	3
X, 1:5, fed b.	23	2
X, 1:5, fed c.	24	1
X, 1:5, fed + MIN[2/]	23	2
Station X, 1:5, unfed a.	25	0
X, 1:5, unfed b.	24	1
X, 1:5, unfed c.[3/]	26	0
X, 1:5, unfed + MIN	22	3
Control sediment, 1:5, fed a.	24	1
" " 1:5, fed b.	18	7
Control sediment, 1:5, unfed a.	24	1
" " 1:5, unfed b.	22	3

[1/] a, b, c are replicate tests.

[2/] + MIN = zoea were observed only at 48 and 96 hours.

[3/] Note miscount where n = 26 rather than n = 25.

TABLE 4

Effects of Within-Station Variability on the 96-hour responses of Dungeness crab zoea to filtered sediment elutriate from four Grays Harbor sites.[1/]

	Alive	Dead
Control seawater a.	25	0
" " b.	24	1
" " c.	24	1
Station X, B1, 1:5, a.[2/]	25	0
X, B1, 1:5, b.	25	0
X, B1, 1:5, c.[3/]	26	0
Station X, B2, 1:5, a.	25	0
X, B2, 1:5, b.	25	0
Station X, B3, 1:5, a.	24	1
X, B3, 1:5, b.	25	0
X, B3, 1:5, c.	25	0
Control sediment, 1:5, a.	25	0
" " 1:5, b.	25	0
" " 1:5, c.	24	1

[1/]All tests were fed.

[2/]B1, B2, B3 = different samples (buckets) of sediment from within station X.

[3/]Note miscount where n = 26 rather than n = 25.

APPENDIX B

STUDY COORDINATION AND PUBLIC INVOLVEMENT

(INCLUDING U.S. FISH AND WILDLIFE SERVICE REPORT)

APPENDIX B

STUDY COORDINATION AND PUBLIC INVOLVEMENT

TABLE OF CONTENTS

July 9, 1965

Col. Charles C. Holbrook, District Engineer
U. S. Army Engineer District, Seattle
1519 Alaska Way, South
Seattle, Washington 98134

Dear Colonel Holbrook:

We ask that you propose through appropriate channels to the Chief of Engineers that he recommend the inclusion of initial funds in the Fiscal 1967 budget to implement Senate authorized review studies and planning on existing Federal facilities for navigation at Grays Harbor. These funds would be for:

1. A review study of the entire harbor area with particular reference to:

   a. The need for development of additional small boat harbor facilities for recreational and commercial fishing boats, and

   b. The feasibility of deepening the main navigation channels on the bar and in the harbor to the depths found to be necessary and economically justifiable.

2. The initiation of advance planning and design work for a major rehabilitation of the deteriorated portions of the north jetty at the entrance to Grays Harbor.

A resolution of the Senate Committee on Public Works requested by Senator Henry M. Jackson, and adopted on December 30, 1957, provides authority for the Corps of Engineers' review study of the entire Federal project known as Grays Harbor and Chehalis River. A copy of this resolution is attached hereto as Enclosure No. 1.

An earlier Senate Resolution requested by Senator Jackson and adopted on October 21, 1957, provides authority for a Corps of Engineers' review study of an earlier report on the Federal project designated as Hoquiam River. This review was to be directed toward improvement of facilities for fishing craft based in the area. A copy of this resolution is attached hereto as Enclosure No. 2.

We feel that one combined and coordinated study of all the Federal navigation projects in the harbor area should be made as soon as possible.

The need for expansion of small boat harbor facilities at Grays Harbor has become urgent in the past few years and this review study should not be delayed any further.

The need for deeper entrance and harbor channels has been emphasized by the use of deeper-draft vessels serving the harbor this past year or so. The converted C-4's operated from Grays Harbor by the Calmar Steamship Corporation are capable of carrying lumber outbound at a draft of 34 feet. The authorized 30-foot project depth restricts these vessels from being loaded to that draft. As a safety precaution, the bar pilots have placed restrictions on nighttime arrivals and departures of the deeper-draft vessels due to restricted channel depths.

Our records substantiate a very definite trend to larger vessels with deeper drafts serving the harbor. Attached as Enclosure No. 3 is a summary of the loaded drafts of vessels crossing the Grays Harbor bar in 1964. You will note thereon that 41 vessels used the authorized 30-foot deep waterway with drafts of 29 feet and up to 33 feet. The fact that these deeper-draft vessels can move only on the high tides causes costly vessel delays.

Another indication of the justification for improvement of the main ship channels is the continuing and substantial growth in tonnage movements through the port. The total annual waterborne commerce over the Grays Harbor waterway reached an all time high in 1964. This reflects clearly on the graph showing inbound and outbound tonnages for the past 10 years (attached as Enclosure No. 4). From all information available to us at this time, we expect that total tonnages over the harbor waterways during the present year will exceed the past year's record high tonnage volume.

As an indication of our confidence in the continued growth of commerce at Grays Harbor, we have begun work on a new pier and bulk commodity storage area which will cost approximately $2.5 million dollars. This capital improvement is to be financed with revenue bonds, the purchase of which indicates that others, too, have confidence in the continuation of port activity and growth. Attached as Enclosure No. 5 is a copy of the news story of this development carried in the Aberdeen Daily World on July 1, 1965.

Our request for your early recommendation for the appropriation of initial funds required by the Corps of Engineers for advance planning and design of a major rehabilitation of the north jetty is in keeping with the Corps' present program of maintaining the existing jetties that afford a sheltered harbor entrance at Grays Harbor. In this regard we would like to express our sincere appreciation to you, and those of your staff who have worked with us, for your excellent cooperation and assistance in getting the south jetty rehabilitation project underway.

Your further cooperation and assistance in getting the study and planning work underway, as requested in this letter, will also be greatly appreciated.

Very truly yours,

PORT OF GRAYS HARBOR

John A. Earley

John A. Earley
President

JAE/of
Enclosures

PORT OF GRAYS HARBOR

GENERAL MANAGER 206 533 9530
TERMINALS MANAGER 206 533-9518
DIRECTOR OF TRADE 206 533 9527
PORT ENGINEER 206 533-9524
DIRECTOR OF MAINTENANCE 206 533-9510
DIRECTOR OF FINANCE 206 533 9504
DIRECTOR OF PLANNING 206 533 9522

P. O BOX 660, ABERDEEN, WASHINGTON 98520

COMMISSION

JOHN H. STEVENS
ROBERT L. AIKEN
GERALD S. TERRELL

HENRY E. SOIKE
General Manager

March 1, 1982

Colonel Norman C. Hintz
District Engineer / Seattle Dist.
U. S. Army Corps of Engineers
P. O. Box C-3755
Seattle, Wa 98124

Ref.: Grays Harbor & Chehalis River
Navigation Channel Improvement Study

Dear Colonel Hintz:

As local sponsors of navigation facilities on Grays Harbor, we are aware of the proposed plan of improvements and are in general agreement with the recommendations of your Seattle District.

We have had the opportunity to review and comment on the draft Fish & Wild Life Coordination Act report on this project. This report proposes mitigation for loss of four acres of inter-tidal habitat above Cow Point. As local sponsors, we will work closely with the private terminal operators, benefiting from the improvements to navigation, to assure that mitigation is accomplished.

It is our understanding that non-federal responsibilities associated with the Highway Bridge and involving a fender system will be provided by the State of Washington Department of Transportation. It is our further understanding that the Union Pacific Railroad will be responsible for bridge replacement cost not covered by the Truman-Hobbs Act which identifies the federal responsibility.

As local sponsor, we are aware of the requirements to dredge berths to match the increased water depths and maintain berth areas through future maintenance dredging as may be required. Port public terminals and industry private terminal operators will share in this responsibility.

The Port will work with owners of utility crossings, above Cow Point, to assure that relocation is accomplished as required and in compliance with the terms of their permits.

Existing congressional authority, through documents and public laws, provides that the Port of Grays Harbor has the right to provide a dredge to do channel dredging at cost under direct contract with the Corps of Engineers. It is our interpretation that the Port's cost include operation, maintenance and depreciation expenses. It is our request that language authorizing improvements to navigation on Grays Harbor again include the Port's historic right associated with dredging.

The Port of Grays Harbor plans to continue as local sponsor and is looking forward to working with the Corps of Engineers during advance engineering and design of this project. We are aware that Congress may modify local sponsor responsibilities. Any changes in non-federal responsibilities resulting from a new public law may require a re-evaluation of our sponsorship.

We are pleased that the revised Feasibility Report will be forwarded to higher authority by the end of FY-82.

Very truly yours,

PORT OF GRAYS HARBOR

H.E. Soike

H. E. Soike
General Manager

HES:dg

23 Aug 1981

NPSEN-PL-NC

Mr. Fred Beeler
Division Superintendent
Union Pacific Railroad
Post Office Box 8979
Portland, Oregon 97208

Dear Mr. Beeler:

This letter is written in followup to conversations between Mr. Alan Coburn, Study Manager for the Grays Harbor Navigation Improvement Project, and Mr. Tom Sheldon and Mr. Richard Welck on 5 and 6 August 1981, respectively, regarding the Union Pacific Railroad bridge over the Chehalis River in Aberdeen, Washington.

As a part of our ongoing study, we are carefully reexamining all aspects of the proposed project, including the need and justification for replacement of the existing Union Pacific Railroad bridge at Aberdeen, Washington.

If the bridge is not replaced, we are assuming that a 85-foot-beam vessel can safely navigate above the bridge. This vessel would require channel depth of approximately 38 feet including allowances for advanced maintenance and contractor tolerance during construction. For purposes of analysis of benefits, we need to know the maximum channel depth that would be allowed at the bridge abutment, including allowances for dredging overdepth and advanced maintenance. Because of our tight study schedule, we would like to have your reply by 1 September 1981. We appreciate the excellent cooperation by your company.

If you have any questions, please contact Mr. Coburn at telephone (206) 764-3651.

Sincerely,

A.P. SELLEVOLD, P.E.
Chief, Engineering Division

UNION PACIFIC RAILROAD COMPANY
TRANSPORTATION DIVISION
DEPARTMENT OF OPERATION

F. BEALER
SUPERINTENDENT
OREGON DIVISION

P.O. BOX 8979
PORTLAND, OREGON 97208

September 30, 1981

R. P. Seilevold, P.E.
Chief, Engineering Division
Department of the Army
Seattle District
Corps of Engineers
P. O. Box C-3755
Seattle, Washington 98124

Dear Sir:

Please refer to your letter dated August 13, 1981, concerning study being made in respect to the proposed Grays Harbor Navigation Improvement Project which will involve Union Pacific Railroad Bridge No. 53.33 over the Chehalis River at Aberdeen, Washington.

In respect to possible channel deepening to approximately 38 ft., wish to advise as follows relative to bridge piers for the railroad structure:

From previous studies made in connection with possible replacement of Bridge 53.33 along with channel deepening, it was determined that the bottom of the piers is 40 feet below mean low water and pilings extend about 40 feet below bottom of the piers. It is our understanding that submarine cables require 10 feet of cover; therefore, if a 38-foot channel depth is dredged, our electrical cable would have to be relocated 48 feet below mean low water.

Wish to quote the following from Corps of Engineers' letter dated January 1, 1979, submitted to our Chief Engineer's office:

> "The 125-foot horizontal clearance of the navigation span opening of the Union Pacific Railroad Bridge over the Chehalis River at Aberdeen, Washington, is inadequate for safe passage of some ships now using the harbor, and for ships projected to the use of the harbor in the future. Additionally, from information and drawings of the bridge received from your Company, the seals of the navigation span piers are at an elevation minus 40 feet MLLW, which would prevent channel deepening more than minus 35 MLLW."

It would, therefore, appear from these previous studies that the maximum channel depth would be 35 feet, without alterations to the pier foundations. The obvious benefit of having a deeper channel is to accommodate

larger ships which leaves our bridge more vulnerable to being struck with resulting greater damage.

Would appreciate your taking this into consideration as study progresses in respect to this proposed project.

Very truly yours,

F. Bealer

F. Bealer
Superintendent

NPSEN-PL-NC

27 AUG 1981

Mr. G. S. Gloyd
Bridge and Structures Engineer
Office of Bridge and Structures
Highway Administration Building
Olympia, Washington 98504

Dear Mr. Gloyd:

As discussed between Andy Soule of my staff and Chuck Mayhan of your staff, we are investigating the feasibility of widening and deepening the existing Federal navigation channel at Grays Harbor, Washington. State Highway 101 bridge at Aberdeen, Washington, is included in the project area which extends from the harbor entrance upstream to Cosmopolis on the Chehalis River. The purpose of this letter is to request Department of Transportation concurrence that widening and deepening the channel through the Highway 101 Chehalis River bridge reach will not adversely affect bridge foundation stability.

The present navigation channel through this reach is authorized at 30 feet below mean lower low water (MLLW); however, recent condition surveys show the actual channel bottom to be from about 32 feet to as much as 55 feet below MLLW. Authorized width is 200 feet.

We are evaluating a full range of widening and deepening options. The deepening options could result in a 40-foot authorized channel which, with advanced maintenance dredging and allowances for dredge tolerances, could result in actual water depths of 42 to 44 feet below MLLW. Widening of the channel in the vicinity of the highway bridge could result in a channel up to 300 feet in width.

Informal staff discussions have indicated no serious potential problems. Presently, no structural modifications to the highway bridge are planned. Submarine power cables may, however, have to be relocated. Again, we wish to confirm that possible widening and deepening within the parameters mentioned above will not have any adverse affects on the stability of the bridge.

NPSEN-PL-NC
Mr. G. S. Gloyd

27 AUG 1981

Request your response by 14 September 1981 in order that we maintain our tight project planning schedule.

Sincerely,

R.P. SELLEVOLD, P.E.
Chief, Engineering Division

JOHN SPELLMAN
Governor

DUANE BERENTSON
Secretary

STATE OF WASHINGTON
DEPARTMENT OF TRANSPORTATION
Highway Administration Building • Olympia, Washington 98504 • (206) 753-6005

September 28, 1981

R. P. Sellevold, P.E.
Chief, Engineering Division
Department of Army
Seattle District, Corps of Engineers
P. O. Box C-3755
Seattle, Washington 98124

Dredging
Chehalis River Bridge No. 101/115

Dear Mr. Sellevold:

Reference is made to your letter dated August 27, 1981, regarding widening and deepening the channel through the subject structure.

The Department of Transportation is unable to give concurrence that widening and deepening the channel in the vicinity of the Chehalis River Bridge No. 101/115 at Aberdeen will not adversely affect the structures foundation stability. We wish to comment as follows:

1. We have experienced some "clear water" scour problems at the west side of the north main pier (No. 15) and at the attached pier protection. Our Hydraulic Office advises that dredging operations may adversely affect this condition.
2. We do not know the section of your proposed dredging, so we can not analyze the amount of unbalanced loading on the piers.
3. A small permanent pier displacement could have very significant effects on the operation of this type of structure (double leaf bascule).

While we support the concept of improved navigational facilities in the Grays Harbor area, and while excavating to minus 44 feet would probably have little, if any, effect on the bridge piers if the channel section remained stable, we can not state that dredging operations as described would have no adverse effects on the piers stability.

We would like to advise you of the concerns of the State and the shipping firms of the potential vulnerability of the bridge piers to ship collisions. We suggest that the Corps' plans for any modifications to the channel recognize these concerns and design the project to mitigate the potential for collisions.

Very truly yours,

C. S. Gloyd

C. S. GLOYD
Bridge & Structures Engineer

CSG:ba
RHK/CEM
cc: R. E. Bockstruck
D. R. Anderson
A. R. Morrell

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
2625 Parkmont Lane, S.W., Bldg. B-3
Olympia, Washington 98502

May 7, 1982

Colonel Norman C. Hintz
District Engineer
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, Washington 981?4

Dear Colonel Hintz:

Enclosed is a copy of our revised draft Fish and Wildlife Coordination Act Report on the Grays Harbor and Chehalis River Improvements to Navigation Project. It is provided, as requested, for inclusion in your draft environmental impact statement and feasibility report scheduled for printing in May. Comments on this draft shall be considered in preparation of the final report scheduled for completion by August 1982.

This report has been prepared under the authority of and in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

To date, bioassay studies of Grays Harbor sediments scheduled for completion during the Feasibility Phase have not yet been completed. By request of your staff, we are providing this revised draft report in advance of necessary completion of those studies. This report is presently based on the assumption that those studies will <u>not</u> discover significant bio-uptake concentration or magnification of contaminants known to occur in sediments which will be dredged during construction. The decision to do so was based on the high likelihood the assumption will prove correct, given known concentrations and the nature of the contaminants. If, in fact, the assumption proves to be incorrect, this report will have to be revised or rewritten to reflect changes in this extremely important underlying assumption, a measure previously agreed to.

If you have any questions or comments, please contact Lynn Childers, Federal Projects Coordinator, or Jeff Opdycke, of my staff, at FTS 434-9440 or (206)753-9440.

Sincerely,

Charles A. Dunn
Charles A. Dunn
Field Supervisor

Enclosure

Grays Harbor and Chehalis River Improvements to Navigation Project

Fish and Wildlife Coordination Act Report

Revised Draft

Ecological Services, Olympia Field Office
Olympia, Washington

May 1982

Fish and Wildlife Service
U.S. Department of the Interior

REVISED DRAFT

FISH AND WILDLIFE COORDINATION ACT REPORT

U.S. Army Corps of Engineers
Grays Harbor and Chehalis River Improvements to Navigation Project

Prepared by:

Jeffrey D. Opdycke, Fish and Wildlife Biologist

U.S. Fish and Wildlife Service
Division of Ecological Services
Olympia, Washington

May 1982

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

This document constitutes the detailed revised draft fish and wildlife report on the Grays Harbor and Chehalis River Improvements to Navigation Project. The project, as proposed by the U.S. Army Corps of Engineers, is located in Grays Harbor County, Washington. The Corps is recommending the dredging of approximately 24 miles of navigation channel with material slated for open-water disposal. Replacement of an existing railroad bridge across the channel is also recommended. The project investigation to date has been accomplished under the authority of resolutions of the Committee on Public Works of the U.S. Senate, adopted October 21 and December 30, 1951. These resolutions authorized studies of Grays Harbor and the Chehalis and Hoquiam Rivers for navigation improvements, erosion protection, and additional small boat facilities.

This report has been prepared under the authority of the Fish and Wildlife Coordination Act, P.L. 85-624, Section 2(b), and in keeping with the spirit and intent of the National Environmental Policy Act (NEPA). This study is limited to the consideration of a recommended plan which has not yet been approved for construction. Findings of this report are based on project data furnished by the Seattle District of the U.S. Army Corps of Engineers prior to April 30, 1982. Prior Service planning aid letters are superceded by this document.

The goal of the Service in its study involvement is to evaluate the impact the Recommended Plan would have on fish and wildlife and their habitat, and recommend methods for preserving and enhancing these resources and compensating for unavoidable losses.

Several assumptions underlie the findings of this draft report. The validity of these assumptions remains to be tested.

Foremost among them regards the present lack of bioassay data. Field studies are now in progress and data should be available prior to finalization of this draft. Recent chemical testing of Grays Harbor sediments (AM Test, 1981) has given us cause to be optimistic about the outcome of the bioassay study. At the request of the Corps of Engineers, we have proceeded under the assumption that no significant mortality, bioaccumulation, or biomagnification will be discovered during the course of the bioassay study. If, however, the findings differ and prove the assumption to be incorrect, this document must be revised or rewritten to reflect that change.

Other assumptions await tests of validity in the Continuing Planning and Engineering (CP&E) phase of project development. For the purpose of the Feasibility phase, we have agreed to the following assumptions:

1. An ocean disposal site can be found within an 8-mile radius of the estuary mouth which, when used, will have no significant long-term impacts to fish and wildlife. Continental shelf disposal appears to be the least damaging reasonable alternative for dredged material disposal. Studies pursued during CP&E will refine project design by determining an acceptable site and method of disposal. Because there is a high

likelihood no significant impact will result, no mitigation in the form of compensation for unavoidable losses is proposed at this time. Again, refinements to project design should, in all likelihood, avoid significant loss.

2. Actual erosion, transport, and fate of dredged material disposed of at the mouth of the estuary is as postulated by the Seattle District Corps of Engineers hydraulic engineers.

3. Modifications to hopper dredging equipment will be developed and tested prior to or during CP&E, which will reduce the entrainment and mortality of Dungeness crabs, again avoiding significant impact.

DESCRIPTION OF THE PLAN

The plan recommended by the Corps of Engineers calls for the dredging of approximately 24 miles of navigation channel. The new channel would follow the course of the existing channel beginning at river mile 2.3 on the Chehalis River, near Cosmopolis, Washington, and ending at harbor mile 21, approximately 2.5 miles seaward of the mouth of the estuary (Figure 1).

Tables 1 and 2 identify major features of the Recommended Plan as of November 19, 1981. Actual dredging depths will be constructed and maintained up to 4 feet lower than authorized depth, allowing 2 feet of advanced maintenance and 2 feet of construction tolerance. Quantities shown include this additional 4 feet of overdepth allowance.

Disposal of dredged material is planned for open water both within the estuary and on the continental shelf. Disposal site locations are shown on Figure 2. Estuarine sites encompass an area large enough to accommodate disposal in progressive stages; disposal would begin at the most oceanward site and progress easterly as the areas are filled and as sea and navigation conditions allow. It is hoped that, in this manner, maximum advantage may be taken of predominant ebb current scour nearest the South Jetty site.

Actual ocean disposal sites will not be determined until biological, physical, and chemical surveys have been conducted during the CP&E phase of the project. Potential sites range from 2.5 to 8 miles off the entrance to the estuary, as shown in Figure 2.

Quantities given in Tables 1 and 2 for Hoquiam Reach include provision of a new turning basin at harbor mile 4.5. Dimensions for the turning basin are 750 feet by 750 feet by 30 feet deep. Enlargement of a present turning basin is planned in the Cow Point Reach located at about harbor mile 2.0. That turning basin would be 1,000 feet by 1,000 feet by 38 feet deep. Turning basin dredging quantities are expressed in the total given for that reach. A third turning basin would be located in the South Aberdeen Reach at about river mile 1.5. This turning basin would replace the one presently located at river mile 2.2. The dimensions are 750 feet by 750 feet by 30 feet deep. Initial dredge quantity is again expressed within the total given for that reach.

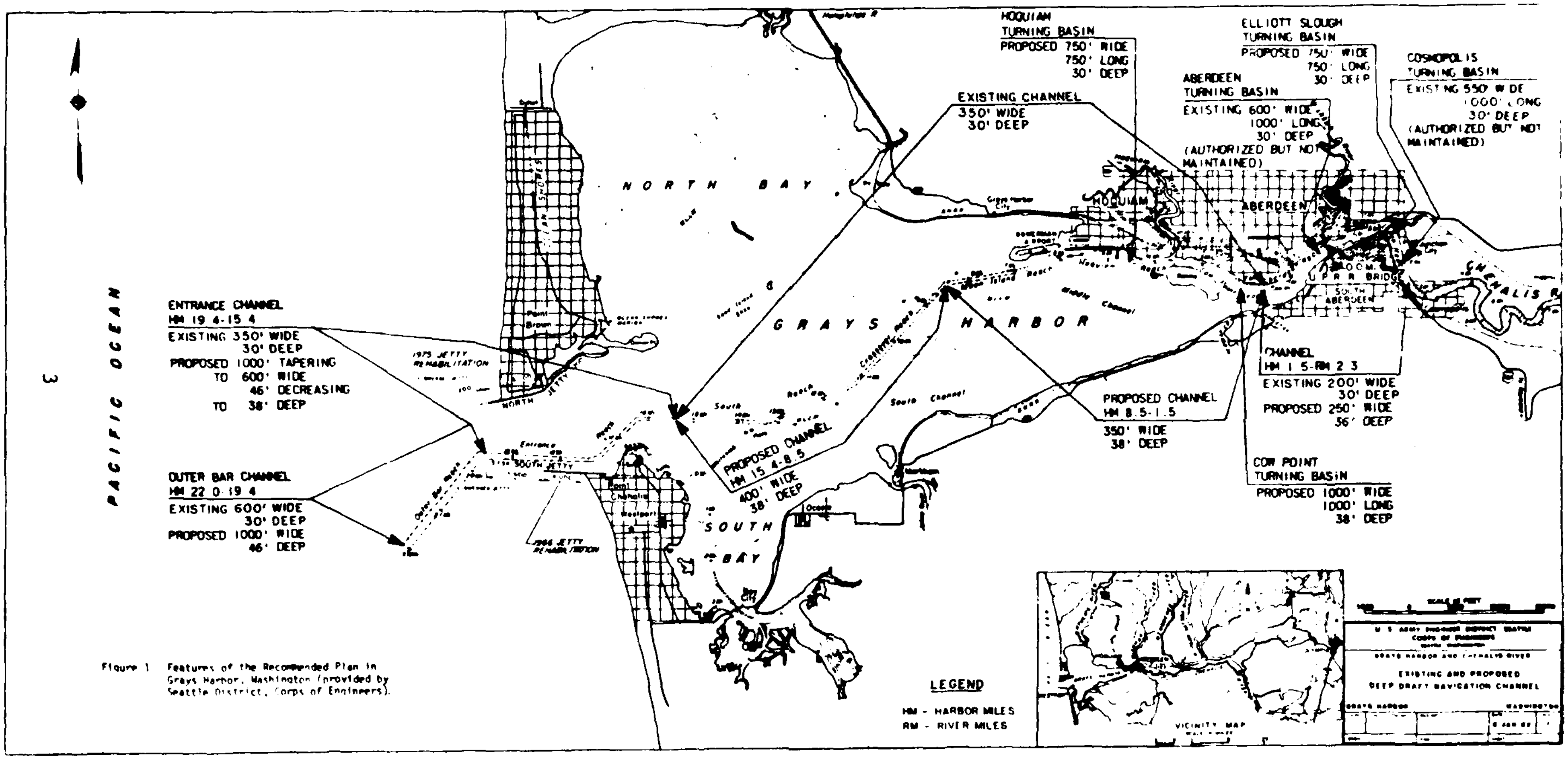


Figure 1 Features of the Recommended Plan in Grays Harbor, Washington (provided by Seattle District, Corps of Engineers).

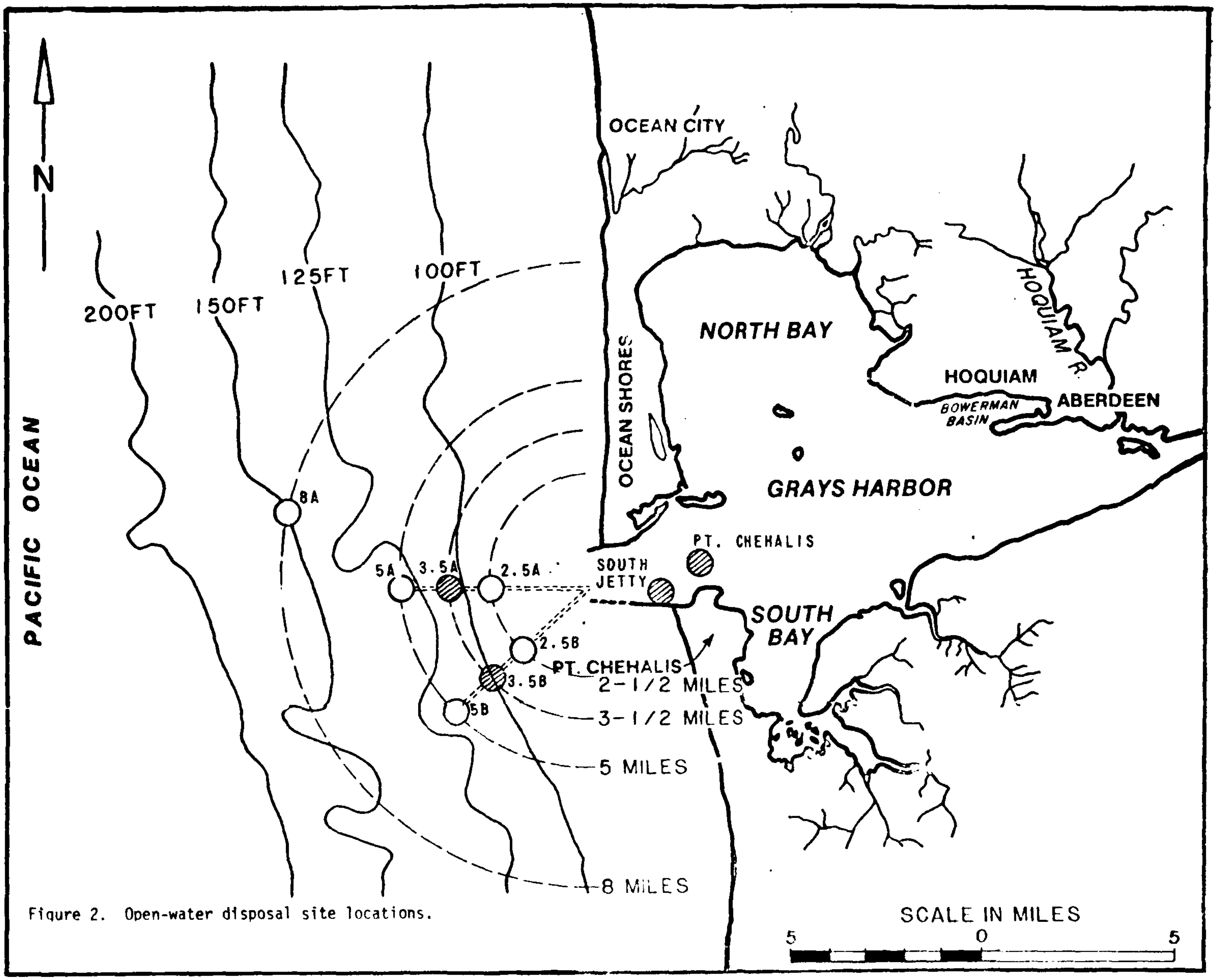


Figure 2. Open-water disposal site locations.

Table 1. Construction features of the Recommended Plan (as of February 1982)

Design Parameters / Dredging Reach	Authorized depth (feet)	Width (feet)	Construction Period	Dredging Equipment Type	Sediment Type	Volume of Material Removed (cubic yds)	Disposal Site
South Aberdeen	36	250	August-December	Clamshell	Sandy silt	1,300,000	South Jetty[1]
Aberdeen	36	250	July-September	Clamshell	Sandy silt	550,000	Ocean
Cow Point	38	350	April-July	Clamshell	Silt/gravel	700,000	500,000 silts to ocean 200,000 gravel to Point Chehalis
Hoquiam	38	350	May-October	Clamshell	Sandy silt	2,150,000	Ocean
Moon Island	38	350	December-April	Clamshell[2]	Silty sand	1,900,000	South Jetty and Point Chehalis
Crossover	38	400	October-December June-July	Hopper	Sandy silt	2,900,000	South Jetty and Point Chehalis
South	38	400	January-March August-September	Hopper	Sand	3,400,000	South Jetty and Point Chehalis
Entrance	46-38	1000-600	September	Hopper	Sand	200,000	South Jetty and/or Point Chehalis as preferred by contractor
Outer Bar	46	1000	May-September	Hopper	Sand	4,000,000	Ocean

1 May require some disposal at Point Chehalis during periods of adverse wave or weather conditions or vessel congestion.

2 Outer portion of reach may be hopper dredged (80% of dredged material).

Table 2. Operation and maintenance (O&M) features of the Recommended Plan (as of February 1982)

Dredging Reach / O&M Requirements	Quantities		Frequency				
	Existing O&M (cubic yards)	Future O&M (cubic yards)	Existing O&M	Future O&M	Dredging location	Sediment type	Disposal site
South Aberdeen	50,000	100,000	Every 5 years	Same (except every 2 years in Turning Basin)	Same (except for Turning Basin	Sandy silt	South Jetty
Aberdeen	50,000	50,000	Every 5 years	Same	Same	Sandy silt	South Jetty
Cow Point	150,000	200,000	Every 2 years	Same	Same	Sandy silt	South Jetty
Hoquiam	50,000	100,000	Every 5 years	Same	Same	Sandy silt	South Jetty
Moon Island	150,000	200,000	Every 2 years	Same	Same	Silty sand	Point Chehalis and South Jetty
Crossover	400,000	450,000	Portions each year	Same	Same	Sandy silt	Point Chehalis
South	400,000	450,000	Portions each year	Same	Same	Sands	Point Chehalis
Entrance	None required	None anticipated	N/A	N/A	N/A	Sands	South Jetty (if needed
Outer Bar	None required	600,000	N/A	½ of channel each 1-2 years	N/A	Sand	Ocean

In addition to dredging, the Recommended Plan calls for the replacement of the existing railroad bridge located at harbor and river mile 0. This feature is recommended to accommodate passage of larger ships to the deepened and widened channel areas upstream from this point. The existing bridge is considered by some to presently pose a hazard to vessel traffic. Horizontal clearance of 275 feet and vertical clearance of 140 feet above mean higher high water (MHHW) are recommended by the Corps of Engineers and U.S. Coast Guard.

Two types of dredging equipment are recommended for project construction; hopper and clamshell.

Hopper dredges are self-propelled and equipped with a hydraulic suction apparatus and a hopper bin to contain and transport the dredged material to the disposal site. At the disposal site, doors on the bottom of the dredge are opened to release the contents. Advantages of this type of dredge include higher mobility, better maneuverability through vessel traffic, and the ability to operate in water too rough for other dredge types. A major disadvantage is that dredging must be interrupted while the vessel travels to the disposal site and empties each load.

Clamshell dredges are one variation of bucket-type dredges. They consist of a grab-bucket device attached by cables to a winch-equipped boom. This mechanism is generally built on a barge. Material is picked up by the grab-bucket and deposited on another barge, with transport to the disposal site provided by tugs. Attributes of this dredge type include ease of operation in confined locations and use of separate disposal vessels so that dredging is not interrupted by time in transport.

DESCRIPTION OF THE PLAN AREA

Deepening and widening of the navigation channel in the Grays Harbor estuary and the disposal of the dredged material will potentially have an effect on a large area composed of two main geographic subdivisions: the estuary itself; and the northeastern Pacific Ocean, principally near the mouth of the Grays Harbor estuary.

Physical Features

The Grays Harbor estuary lies at the mouth of the Chehalis River in southwestern Washington 40 nautical miles north of the entrance to the Columbia River (Figure 3). It is the third largest estuary in the U.S. north of San Francisco Bay (11 nautical miles wide and 15 nautical miles long), smaller than the Columbia River and Willapa Bay estuaries to the south. Fresh water inflow to the estuary comes predominantly from the Chehalis, Hoquiam, and Humptulips Rivers. Precipitation is high, increasing from about 80 inches (200 cm.) near the estuary to over 220 inches (550 cm.) in higher reaches of the watershed. Peak river discharge occurs in the winter, associated with winter storms, while low flows occur in the months of August and September. The predominant physical feature of the Grays Harbor estuary is the vast amount of intertidal mud and sandflat. Of the total area of the estuary, 91 square miles, 38 square miles are intertidal.

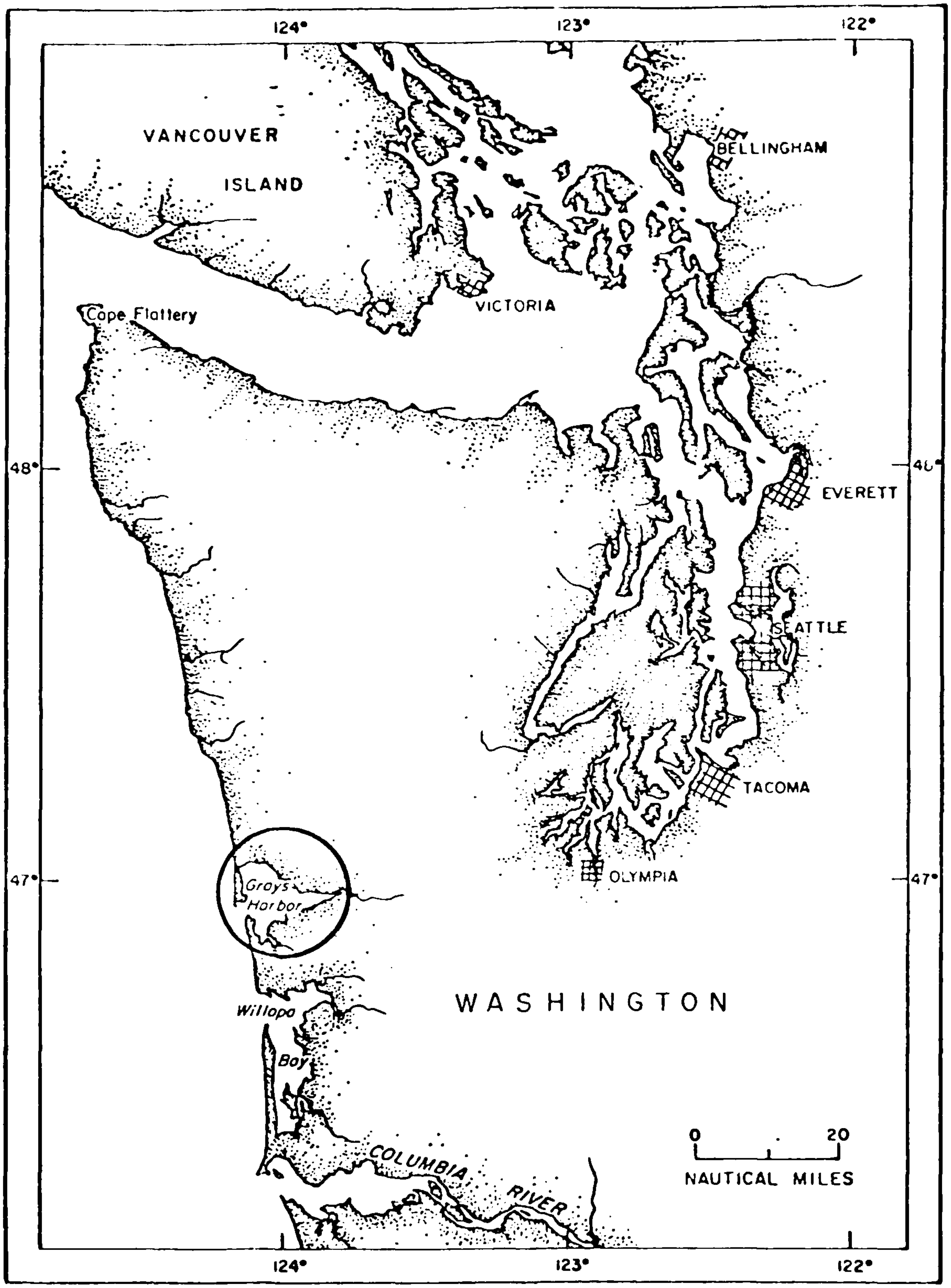


Figure 3. Project location (from Loehr and Collias, 1981).

Grays Harbor sediments can be divided into three types: ocean-borne sand, river-borne silt, and a transition zone of mixed sand and silt.

Ocean-borne sand occurs in the outer estuary nearer the ocean, while river-borne silt predominates the areas of river outfalls in the northern, southern, and eastern lobes of the estuary. The mixed transition lies between the two in a broad band. According to Nittrauer (1978), Grays Harbor seems to represent the northern limit of significant transport of the nearshore Columbia River sands. Sands in the outer estuary, as well as beaches north and south of the estuary mouth, are of Columbia River origin (Scheidegger and Phipps, 1976).

Numerous shallow channels have been cut into the intertidal mudflat areas of the north, south, and east bay regions by ebbtide flows and discharge from the Humptulips, Elk, and Chehalis Rivers, respectively. Most extensive are the two channels along the north and south shores of the eastern harbor area carved by the Chehalis River. The north channel has been dredged for navigational purposes, while the south is largely untouched and much shallower. Naturally scoured deep-water areas occur near the mouth of the estuary where depths of up to 80 feet are encountered.

The Pacific Ocean is the dominant feature of the project area. The coastline is oriented in a north-south direction as a series of sandy beaches interspersed with rocky headlands. The coast is subjected to the full impact of severe winter storm-produced waves. The winter wave environment produces turbulent mixing from surface to bottom over the Continental Shelf, affecting productivity, water column characteristics, and sediment transport processes. This area is influenced heavily by the Columbia River freshwater discharge or plume (see Figure 4) which flows northward nearshore during the winter, due to prevailing winds. During the summer months, the plume changes direction to the south and west, and the climatic conditions creating this response cause nearshore surface water to move offshore, being replaced by deeper water, a feature known as upwelling. Upwelling brings deeper, cooler water, high in nutrients, to the surface, affecting regional weather conditions and coastal biological productivity.

The continental shelf along the Grays Harbor coast varies from 30 to 36 miles in width. A definite change in slope occurs at about the 600-foot depth contour, the beginning of the continental slope and a descent to the abyssmal ocean depths. Bathymetry of the shelf (shape of the ocean bottom) focuses wave energy which significantly affects coastline topography and, in some cases, human development on shoreline areas.

Continental shelf bathymetry has been carved by wave action over millions of years. Changes in sea level during this period have allowed waves to work over the width of the present shelf. The nearshore gradient (out to 3 miles) off Washington is more gradual than any other area of the shelf between Cape Mendocino to the south and Cape Flattery to the north.

Composition of the shelf bottom consists of various sediment types. Broadly speaking, there are three distinctive types: fine sand, mid-shelf silt or mud, and relict gravels (Smith et al., 1980). Fine sand is exposed nearshore

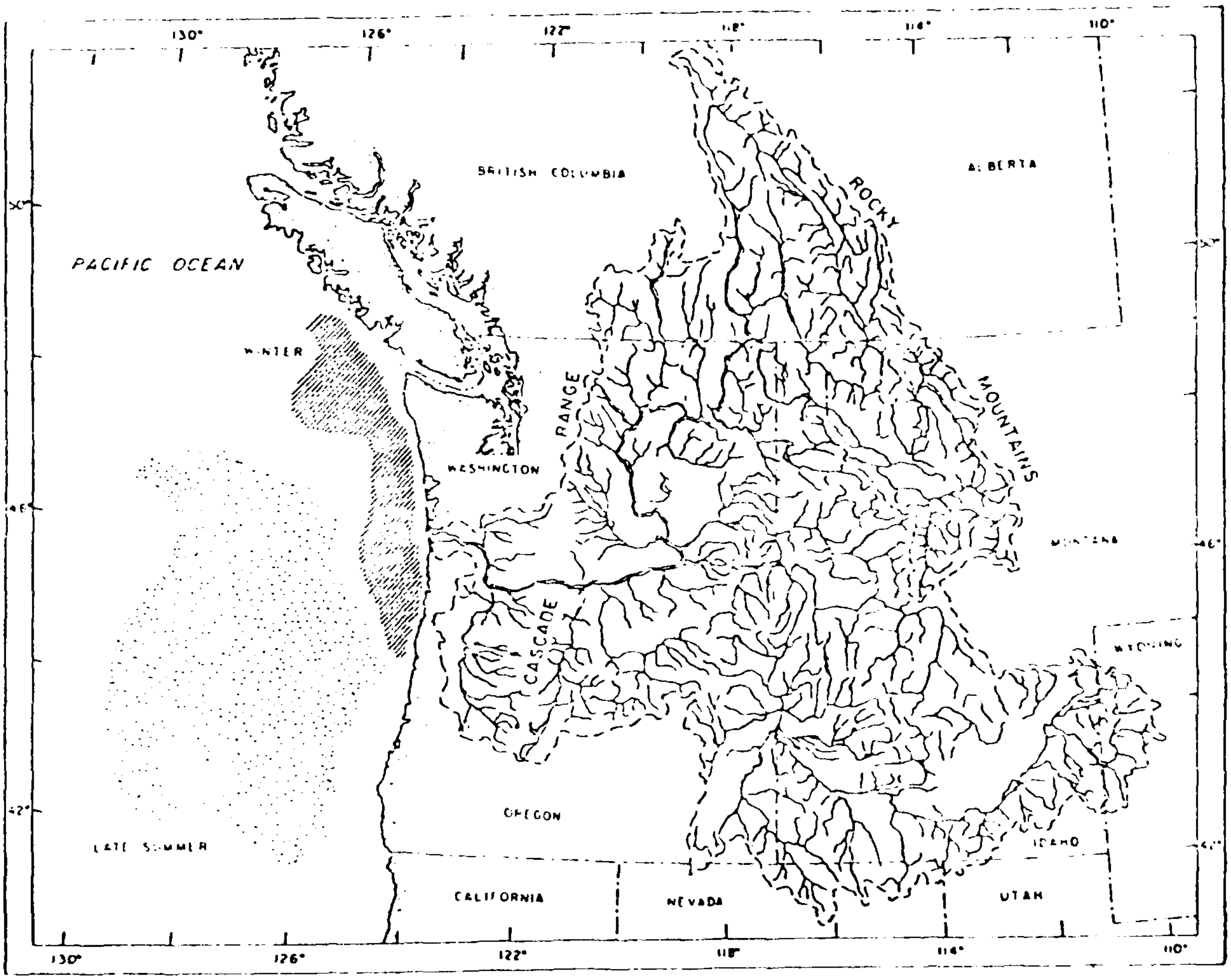


Figure 4. Columbia River drainage basin and average seasonal extent of the Columbia River plume offshore (from McGary, 1971).

and in select patches near the outer edge of the shelf. The mud or silt facie is located in the mid-shelf region and is, in many places, seasonal; where it exists permanently, it is in dynamic equilibrium often associated with large river plumes (Proctor et al., 1980). Physical processes which affect this sediment type are seasonal in nature. These include precipitation and runoff, wind and waves, and ocean currents. During the summer months of low wind and wave activity, the mid-shelf region is covered with a layer of silt. This silt deposit is resuspended by winter wave action, leaving clean sand covered with active wave-induced ripple marks (Proctor et al., 1980). Silt is eventually transported to the continental shelf and into the abyss. Relict gravels occur off Grays Harbor to the west and north in a large north-south patch (Smith et al., 1980).

Fish and Wildlife Resources

Fish and wildlife resources of the area are both diverse and abundant. The high productivity of the shallow and expansive estuary, coupled with the effects of moderate climate, high coastal oceanic productivity, and low intensity urban and industrial disturbance, create an area rich in flora and fauna. Extensive eelgrass beds of varying densities are located throughout the estuary, in addition to expanses of sparsely vegetated intertidal mud and sandflats. Offshore, the rich supply of nutrients brought to the photic zone by upwelling stimulates the growth of phytoplankton, resulting in a conspicuous bloom of plant life which, in turn, drives zooplankton production and organisms of higher trophic levels. The success and timing of the fisheries in this region are closely correlated with this chain of events (OSU, 1971). Major commercial and recreational fin fish species include albacore, sole, coho salmon, chinook salmon, rockfish, sablefish, ling cod, and smelt. Major shellfish species harvested in the area include razor clams, Dungeness crab, oysters, and shrimp. The estuary itself is utilized by at least 52 species of resident and anadromous fish during various stages of their life history (Proctor et al., 1980). The estuary provides a pathway and nursery area for the valuable anadromous fish of the region. A portion of the outmigrant juvenile chinook salmon population remains in the estuary for an extended interval of time following downstream migration (Simenstad and Eggers, 1981). Salmon species use the estuary as a feeding area and transition zone while changing to a saltwater metabolism.

The Grays Harbor estuary is a major wintering and resting area for migratory waterfowl and shorebirds of the Pacific Flyway. Black brant, American widgeon, mallard, pintail, canvasback, and Canada goose are the major hunted species.

Spectacularly large concentrations of shorebirds occur in and around the estuary during annual north/south migrations. Peak numbers, composed primarily of western sandpipers and dunlin, occur in April and May with upwards of 1,000,000 birds utilizing the estuary in a single day (Herman and Bulger, 1981).

Grays Harbor estuary is also extensively used by fish-eating waterbirds, gulls and terns, terrestrial birds, and raptors, most notably the threatened bald eagle and endangered peregrine falcon (*Falco peregrinus anatum*). Various

islands in the estuary are known to be significant harbor seal haul-out (resting) areas.

The wetland areas in the floodplain of the Chehalis River, east of the city of Aberdeen, provide excellent habitat for birds and furbearing mammals. Populations of beaver and muskrat sustain commercial trapping activity in the area. Predators such as bobcat, cougar, bear, and coyote, are also occasionally found there.

Grays Harbor estuary is composed of habitat types made distinctive by virtue of one or more characteristics: substrate type; elevation with respect to tidal influence; and predominent vegetation. There are five habitat types found in the estuary; channel, mudflat, sandflat, eelgrass, and emergent vegetation.

Channel habitat is distinguished as a naturally-occurring or dredged portion of the estuary which is significantly deeper than the adjacent shallower flats (Proctor et al., 1980). In Grays Harbor, this deeper subtidal habitat is by and large man-made, consisting of the dredged channel running the length of the estuary, from the mouth to the riverine area of Cosmopolis. It is most confined near its eastern terminous, broadening as it approaches the estuary mouth. It is there that naturally deeper areas occur, resulting from natural scouring action of tides constricted by the mouth of the estuary. Present dredged channel habitat in the Grays Harbor estuary encompasses approximately 565 acres.

The food web in the channel begins with water column phytoplankton and detritus exported from other habitats. Diatoms dominate the phytoplankton. Because of depth and turbidity, there are no benthic primary producers in the channel. In deeper areas, respiration and decomposition, coupled with reduced river flows, may produce low DO concentrations, thereby reducing population sizes and modifying species composition. DO problems have been especially acute in the past in the Aberdeen Reach. Characteristic fauna include a predominance of copepods in the zooplankton, starry flounder, staghorn sculpin, sharks, lingcod, and salmon. Harbor seals forage here, as well as birds such as grebes, cormorants, and scoters.

Mudflat habitat in the Grays Harbor estuary is characterized as sub- and intertidal, river-borne silt deposits radiating from the mouths of the major rivers emptying into the estuary. No emergent vegetation exists in this habitat, and the predominant flora is restricted to epibenthic algae.

Current velocities, light penetration, or other factors prevent the growth of eelgrass. Diatoms dominate the phytoplankton, and are present with green and blue-green algae on the bottom. This habitat is of special value to juvenile salmonids during their outmigration and to English sole (Simenstad and Eggers, 1981).

Vast expanses of intertidal mudflats, which are exposed at low tide, are available for use by shorebirds. U.S. Fish and Wildlife Service aerial shorebird and waterfowl counts conducted with the cooperation of the Washington Department of Game (Kalinowski et al., 1982), found this habitat to

be used extensively during coastal shorebird migrations. Herman and Bulger (1981) found shorebird numbers in the estuary peaked April 23-24 in 1981 with approximately 1 million birds sighted. During ebbing and low tide, shorebirds such as western sandpiper, sanderling, yellowlegs, dunlin, dowitchers, and curlews use the habitat for feeding purposes. During high tides, birds such as western grebe, scoter, cormorant, and great blue heron are present.

Primary production in mudflat habitat is dominated by phytoplankton consisting mostly of diatoms. Zooplankton is dominated by copepods and mysids. Of the fish species, starry flounder, staghorn sculpin, and sticklebacks are the most common residents. The benthos includes primarily softshell clams (Mya arenaria), bent-nosed clams (Macoma nasuta), and polychaete worms.

Subtidal sandflat habitat is found in the outer harbor, just inside of the estuary mouth and extending toward the north, south, and inner harbor lobes of the estuary. This habitat is generally bounded toward the nearshore by eelgrass habitat at the point where coarse ocean sands mix with finer river-borne silts. No attached vegetation exists and there is very low epibenthic algal production. Water column characteristics are the same as for subtidal mudflats. Phytoplankton is the primary producer. Organic detritus is generally less available than on the mudflat. Detrital and deposit-feeders are less abundant. As a result of greater wave action and current velocity, sand particles become coarser and less stable nearer the estuary mouth. Here benthic populations and organic matter are reduced.

Eelgrass (Zostera spp.) habitat encompassed 20,810 acres of the Grays Harbor estuary in 1977 (Miller, 1977). Approximately 10,000 acres of this total was considered to be dense beds. Eelgrass seems to prefer a mix of sand and silt substrate. It lives in areas of moderate current velocity from mean lower low water to 20-30 feet (6m to 9m) deep where it is the major primary producer. In Grays Harbor, depth is limited to roughly -3 feet MLLW because of high turbidity. Areal extent and density may change from year to year as old beds are uprooted and new ones established.

Eelgrass habitat is of particular importance in the estuary, as it provides food, shelter, and substrate for an abundance of marine organisms and, in general, increases the biological productivity and diversity of the estuary. Abundant roots and rhizomes have a binding effect on the substrate which stabilizes the bottom sediments, increasing the rate at which suspended sediments accrete, and reducing the erosive forces of local currents. As such, it plays an important role in the natural succession of subtidal to intertidal estuarine habitat (Proctor et al., 1980).

Eelgrass habitat is significant as an ecological link between other estuarine and offshore habitat types. Eelgrass produces an abundant yearly crop of vegetable matter which is exported from the immediate habitat as detritus. This material can be found almost anywhere within the estuary, as well as offshore along the continental shelf and on ocean beaches. It provides organisms in these habitats with a rich source of food during the less productive winter period (Proctor et al., 1980).

A myriad of organisms inhabit eelgrass beds. Benthic fauna include nereid worms, clams, nematodes, and burrowing anemones. The leaves support isopods, amphipods, hydroids, bryzoa, harpacticoids, herring spawn, snails, limpets, protozoa, ciliates, and nudibranchs. Juvenile salmonids, striped sea perch, pipefish, and blennies find food and cover in the eelgrass beds. The epibenthic area is home to flatfish (sole and flounder), crabs, and moon snails.

Eelgrass is an important food item for waterfowl, especially black brant and widgeon. Yocum and Keller (1961) concluded that eelgrass was the single most important item of food for waterfowl migrating through Humboldt Bay, California, on the basis that widgeon and black brant constituted 47 percent and 20 percent, respectively, of the total waterfowl populations in the area and that eelgrass constituted 81 percent of the volume of the diet of both these species. McRoy (1966) estimated that black brant and Canada geese consumed about 17 percent of the standing stock of eelgrass in Izembek Lagoon, Alaska, during the summer-autumn feeding period. He estimated that each bird required about 1 square meter of eelgrass per day. Eelgrass is also a food item for canvasback, scoter, and coot. Smith and Mudd (1976) have studied the food habits of waterfowl and shorebirds in Grays Harbor Washington, with similar conclusions as to the importance of eelgrass.

As illustrated in the eelgrass habitat food web (Figure 5), man is a direct beneficiary of the production of this ecosystem in the harvest of waterfowl, fish, clams, and crabs.

Emergent vegetation, in the form of saltmarsh and freshwater marsh, fringes the estuary in areas of tidal influence and low-energy wave conditions. Characteristic flora include three-square bulrush (Scirpus americanus), arrowgrass (Triglochin moritimum), spike rush (Eleocharis macrostachya), sand spurry (Spergularia marina), salt grass (Distichlis spicata), bulrush (Scirpus validus), and Lyngby's sedge (Carex lyngbyei). Fauna typically include black brant, Canada goose, scaup, mallard, widgeon, canvasback, bald eagle, kestrel, muskrat, vagrant shrew (Sorex vagrans), and Townsend's vole (Microtus townsendii).

Detrital productivity of the area is exported to other habitat types during spring tides and thus contributes to the marine food web.

Emergent vegetation habitat has been significantly reduced in the Grays Harbor area through diking, filling, spoil disposal, and ditching. Because it is a transitional zone between nearshore lowlands and the water, it is susceptible to alteration for use as pastureland or urban/industrial development. Today, emergent vegetation habitat comprises only 16 percent of the Grays Harbor intertidal area. Since the early 1900's, some 1,540 acres (625 ha.) of wetlands, presumably mostly emergent vegetation habitat, have been permanently committed to upland usage. The rate of habitat removal increased following 1950, as 1,280 acres (500 ha.) of that total have been altered to uplands since that date. However, since 1972, wetland loss has slowed substantially. Permanent loss represents approximately one-half of the previously existing wetlands, with an additional unknown quantity periodically affected by spoil disposal. The U.S. Army Corps of Engineers (1976) reports 3,849 acres

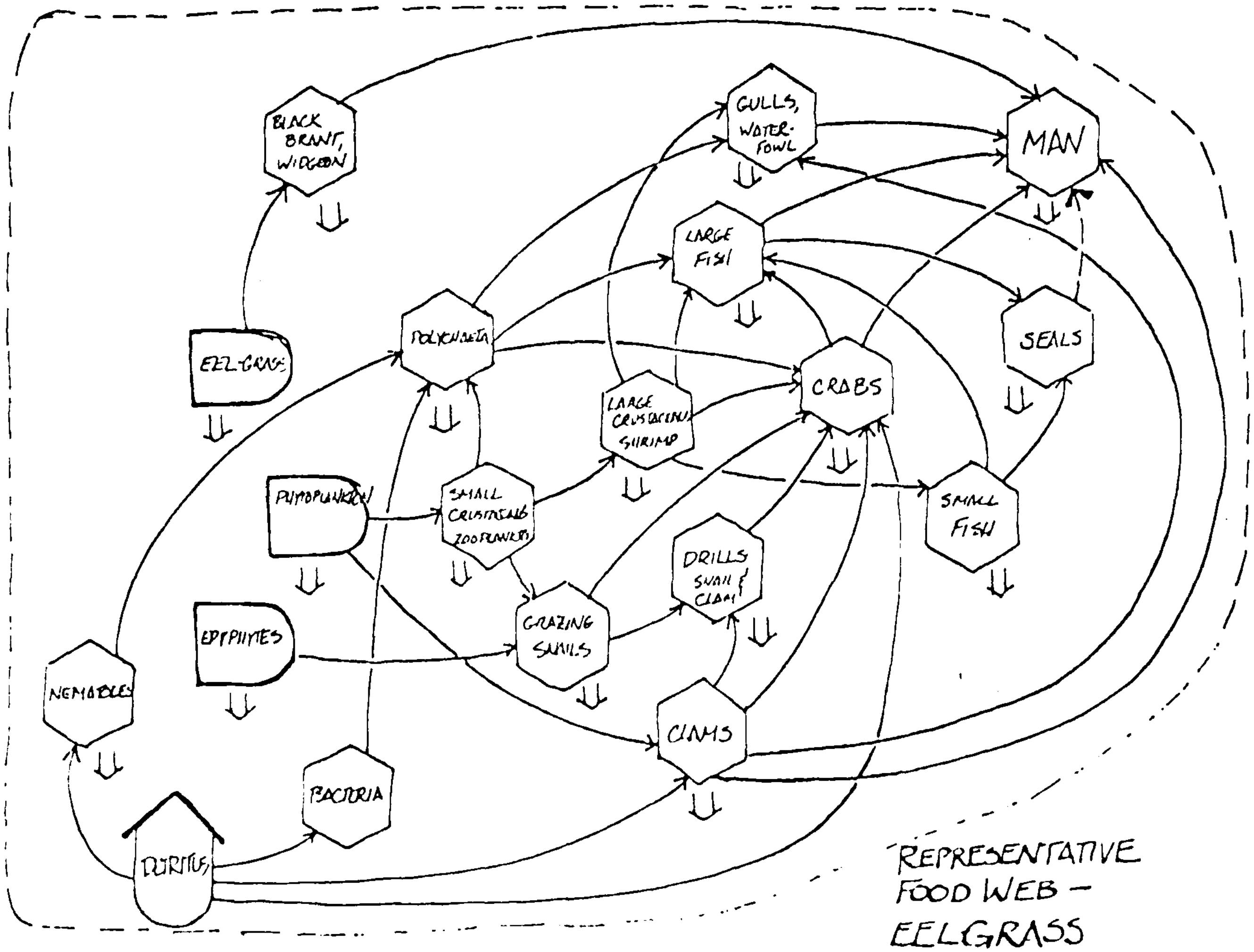


Figure 5. Generalized foodweb relationships - eelgrass habitat.

(1,500 ha) of intertidal land within Grays Harbor has been utilized for disposal of dredged material. The figure represents 11.4 percent of the total intertidal lands (33,500 acres or 13,600 ha), with an average annual usage of 110 acres (45 ha).

The continental shelf of the Pacific Ocean off Grays Harbor is composed of five general habitat types. The pelagic zone exhibits two types; the upper water layer penetrated by sunlight, known as the euphotic zone, and the water column beneath where sunlight does not penetrate, known as the disphotic zone. The sediments of the ocean bottom and the water just above them can be divided into three more habitat types based on the character of the sediments. All are known as "benthic" and the three types are rock, silt, and sand.

The pelagic euphotic habitat receives sunlight sufficient for photosynthesis. The depth of this layer varies seasonally and locally, ranging between 60 and 260 feet (Proctor et al., 1980). The flora are dominated by diatoms. Zooplankton include copepods, euphausids, salps, shrimps, and amphipods in the zooplankton. Lantern fish, anchovy, squid, and salmon are characteristic of the nekton. Other fauna include baleen whales, porpoises, California sea lion, and cormorants.

Pelagic disphotic habitat lies beneath the pelagic euphotic and is too deep for sunlight to penetrate. During daylight hours, it is the home of pelagic carnivores which move to the surface at night to feed. Grazing and detrital food chains are based on primary production occurring in the euphotic zone above. Flora are insignificant. Fauna include lantern fish, baleen whales, and shrimp.

Benthic rocky habitat is composed of rocky substrate of rough, irregular terrain. The food web is based on detritus from production in overlying waters. Fauna include barnacles, sea anemones, tube worms, starfish, crabs, halibut, and rock fish.

Benthic sand habitat consists of relatively hard, smooth sand beyond the influence of surf conditions and longshore currents. This habitat gradually grades into the silt bottom as the water deepens to the west. The food web is driven by detritus drifting down from the pelagic euphotic habitat above. There are no primary producers on the substrate. Characteristic fauna include polychaete worms, gammaridian amphipods, Dungeness crab, English sole, Pacific sanddab, and butter sole.

Benthic silt is level-bottom habitat that is predominantly composed of sediment grains less than 0.062 mm in diameter. Community composition is more abundant and diverse than that of sandy sediment habitat. The food web depends on detrital production from overlying waters. Few plants are found due to low levels of light. Fauna include sea urchin, epifaunal invertebrates, shrimp, Dover sole, flounder, and sable fish.

<u>Socioeconomic Features</u>

Human development and intensive land use is located principally in and near the cities of Aberdeen, Hoquiam, and Cosmopolis, all situated around the inner

estuary. The socioeconomic environment of the Grays Harbor region is strongly influenced by fluctuating levels of its natural resource-based economy. Economic activities associated with the production, harvesting, processing, transporting, and marketing of resources and with recreational use of the collective coastal environment constitute the economic base of the Grays Harbor region. The economic base provides the driving force behind the region's social organization and activity, including the distribution and composition of its populations, occupational and employment characteristics, physical growth and development, and community attitudes. To date, relatively little employment or income is derived from activities not directly linked to local natural resources (Proctor et al., 1980).

Major commercial activities within the plan area are forest products, fisheries, and recreation. Much of the area's wood processing and export occurs at publicly- and privately-owned facilities located around the inner estuary.

The predominance of the forest resource has diminished somewhat as old growth on private lands is harvested. This trend, and a reassessment of the value of the forest resource for other uses, is contributing to increasing interest in other income producers such as fisheries and tourism.

Fresh and salt water in the Grays Harbor area provide excellent habitat for many commercially harvested fish and shellfish species. These waters include the northeastern Pacific Ocean and the rivers and streams of Grays Harbor and adjacent counties, as well as the Grays Harbor estuary itself, which forms a broad transitional area from fresh to salt water. Boat moorage and fish processing capability make the estuary a popular port for the coastal fishing industry.

Predominant fish species harvested include tuna, salmon, and bottomfish (or groundfish) such as sole, cod, and perch, while important shellfish are oysters, clams, crabs, and shrimp.

In 1975, fishery resources earned at landing $10,951,819. This represented 17.5 percent of the total value of the State harvest. Table 3 gives an indication of the importance of this economic activity.

Salmon harvesting is a significant portion of the fishing industry, both in the open ocean and the estuary. The town of Westport is a base for a well-known recreational ocean salmon fishery, with an average of over 300,000 fish taken per year (Proctor et al., 1980). Strict, but variable, fishing regulations govern harvest activities; however, overfishing and degradation of rearing and spawning habitats in estuaries and streams have contributed to an overall decline in harvestable salmonid populations. These conditions have prompted State and Federal assistance in the form of fish hatcheries, which have stabilized and subsidized the industry to a great extent. The delicate ecological character of salmon spawning grounds and the threat of overfishing requires strict, and often controversial, regulation of salmon harvesting and spawning ground conditions.

Table 3. Seafood landings, Grays Harbor District, 1966-1975 (thousands of pounds) (from GHRPC, 1979)

	Salmon	Bottom fish	Other food fish	Shellfish	Total
1966	6,268	1,735	4,263	8,142	20,408
1967	6,815	933	19,708*	6,761	34,217
1968	5,692	467	954	6,370	13,483
1969	5,087	522	1,534	14,311	21,454
1970	7,918	699	1,473	11,847	21,937
1971	7,652	936	6,106	8,498	23,192
1972	5,475	1,973	4,470	8,758	20,676
1973	8,211	3,624	3,312	4,326	19,473
1974	8,754	5,675	4,413	5,068	23,910
1975	6,518	4,263	6,835	6,802	24,418
% of State in 1966	19.4	3.3	13.1	39.4	14.7
% of State in 1975	14.4	11.1	17.4	25.2	16.3

*Included 19,221,301 pounds of hake.

Salmon landings have been inconsistent and have recently begun a decline. This problem is further intensified by a range of legal and technical problems and issues which affect fishing season and allowable catch.

Albacore tuna is a migratory pelagic species found in temperate zones world-wide. Fish populations in the area vary with ocean currents and water temperature, and levels of harvest vary accordingly. Albacore tuna is usually harvested within the 200-mile limit.

Bottomfish are gaining in commercial harvest importance since enactment of the 200-mile Fishery Conservation Zone. These fish species hold great potential for future development (Wash. Pub. Ports Assoc., 1980; GHRPC, 1981). Bottomfish, including rockfish, lingcod, greenling, cabezon, flounder, and sole are taken in well-defined areas throughout the region. Bottomfish catch for the Grays Harbor fishing fleets has shown a growth of 600 percent since 1970. Catches of, specifically, flounder and sole grew by 1,000 percent between 1970 and 1974 (USACE, 1976).

Dungeness crab is found along the continental shelf and in the Grays Harbor estuary at depths of 50 fathoms or less (USACE, 1971). Although crabs are not plentiful in all areas and the populations are very cyclic, productive grounds can be reached by fishermen up and down the coast.

Dungeness crab landings at the town of Westport near the estuary mouth amounted to 66 percent of the total coastal poundage of 3.48 million pounds. Of the total value of fisheries products landed at Westport of $1.2 million (a value surpassed in the State by only one other receiving port), Dungeness crab comprised 21.7 percent (Nosho et al., 1980).

Volume of Dungeness crab catch has been very erratic. A particularly sharp decline occurred between 1970 and 1974. During this period, landings dropped 75 percent along the Washington coast. Research at Oregon State University relates fluctuations in crab landings to rainfall, which affects the salinity of estuaries where crab larvae mature (Lough, 1974).

Shrimp harvests increased enormously along the Washington coast from 1970 to 1974 from 800,000 pounds per year (OIW, 1977) to over 9,000,000 pounds (Wise and Thompson, 1977).

Razor, hardshell, and softshell clams are harvested in the estuary and along the nearby Pacific Ocean coast. While most are dug for sport, a substantial commercial razor clamming endeavor does exist on the coast of the Quinault Indian Reservation to the north.

The largely unspoiled natural recreation attractions of both coastal and inland areas, historic sites, and fish and wildlife resources have spurred tourism to an income producer second only to forest products. The ocean coastline, beaches, and harbors set the stage for a variety of recreational activities. In addition to fishing, camping, and hiking opportunity, the preserved natural scenic beauty of the coastline makes pleasure driving an important recreation along US 101 and other highways. Sportfishing resources, both ocean and fresh water, are among the most significant generators of recreational activity in the area (Proctor et al., 1980).

FUTURE WITHOUT THE PROJECT

Physical/chemical features of the Grays Harbor area are not expected to change significantly without the project. Channel maintenance can be expected to continue under conditions very similar to those of today. No ocean disposal is anticipated. Because no significant growth in socioeconomic activity is expected without channel improvements, there should be no corresponding impacts to atmospheric, hydrospheric, or lithospheric features of the Grays Harbor area.

Forestry and forest products will probably remain the major industry of the region over the project life. However, the relative importance of the industry in the long term is dependent upon a complex set of factors. These include continued productivity increases and their related employment decline, withdrawal of timberland from commercial harvest (such as roadless areas, parks, etc.), changes in the overall price of wood products, and forest management practices.

The outlook for the forest industry suggests severe economic dislocations in the future. A combination of factors is involved: increasing logging and transportation costs, environmental controls on logging operations, and watershed management; multiple use priorities for public forest lands; and continued productivity increases and accompanying employment losses (Proctor et al., 1980).

Without the project, cycles of boom and bust in the forest products industry will likely continue. When the forest products market is booming, in particular the Japanese market, there will be room for Grays Harbor. The increased demand will overshadow the increased costs of shipping out of Grays Harbor's smaller channel. In poor years, the increased shipping costs will become a competitive disadvantage and Grays Harbor will lose a portion of its market share (Dugan, Personnal Communication).

The same conditions hold true for the local transportation sector as well, especially waterborne shipping. Because this sector is presently dependent upon forest products, it too will follow the cycles of the forest products industry.

Fishery industry forecasts, depite the present unsettled state of salmon harvest, generally look good for the coastal region. The primary factor responsible for this optimism is the 200-mile fishing zone, or Fishery Conservation Zone (FCZ), established by enactment of the Fishery Conservation and Management Act (FCMA) of 1976.

Bottomfish landings are expected to increase dramatically through the year 2000 (Washington Public Ports Assoc., 1980). Of the many species of bottomfish, hake (or Pacific whiting) represents the most valuable untapped fishery resource. The Ports' report states, "The combination of an increased fishery product demand due to the U.S. consumer's growing concern about nutrition, of technology development in world fishing practices, and of the extension of the FCZ has given the U.S. fishing industry the opportunity to greatly expand its share of world fisheries production."

AD-A115 779 CORPS OF ENGINEERS SEATTLE WA SEATTLE DISTRICT F/G 13/2
INTERIM FEASIBILITY REPORT AND DRAFT ENVIRONMENTAL IMPACT STATE--ETC(U)
JUN 82

UNCLASSIFIED NL

4 OF 6
AD A
115 779

A 1971 Oregon Fish Commission biomass survey estimated that hake comprises 40-45 percent of bottomfish on the continental shelf between the Columbia River and Port Orford, Oregon (Kuhn et al., 1974, from Demary and Robinson, 1973). Sole, sanddabs, black cod, and anchovies are also potentially exploitable resources along the coast (Kuhn et al., 1974; USACE, 1975). Scallops are believed to be plentiful off the coast and may also prove to be exploitable (USACE, 1975).

Overall demand for fish in the U.S. is strong. From 1970 through 1974, average per capita consumption increased from 11.8 to 12.2 pounds (Wise and Thompson, 1977). World-wide demand for protein also appears to have kept demand for fish high (Kuhn et al., 1974).

As for salmon, it is hoped that watershed restoration activities, combined with improved hatchery practices and sound harvest management, will assist in raising salmon population levels maintaining the salmon-related portion of the fishing industry.

Without the project, no significant departure from commonly held fisheries forecasts would result. Vessels necessary to harvest and process bottomfish in the future will not exceed current allowable depths and plentiful moorage is available in the outer harbor area at Westhaven Marina.

Long-term demand for recreational services depends on the amount of leisure time and personal income available to the potential market population. Overall trends in the U.S. indicate that leisure time and personal income are rising, so it can be reasonably expected that demand will continue to increase (Schmisseur and Boodt, 1975). For the Grays Harbor area, this increase should be especially significant due to the growth in nearby Puget Sound, and the cities of Everett, Seattle, Tacoma, and Olympia south to Chehalis. The natural recreational advantages of this coastal area noted earlier place it in an ideal position to satisfy increased demands for recreation.

The services industry will mirror changes in the basic activities of fisheries, recreation/tourism, forestry and forest products, and transportation. Increases in this sector would therefore appear to follow a general growth of fisheries into bottomfish harvest and processing, as well as the expected growth in recreation/tourism.

FUTURE WITH THE PROJECT

Predicted Physical/Chemical Changes

Approximately 7.2 million cubic yards of material dredged during construction is recommended by the Corps of Engineers for open-ocean disposal over the continental shelf. The Corps of Engineers is considering sites between 2.5 and 8 miles distance from the mouth of Grays Harbor. Therefore, effects of disposal will be generalized for the nearshore area of the continental shelf.

Continental shelf disposal is, in this case, a more costly disposal alternative. It has been recommended by the Corps for a sizable portion of dredged material as a method of avoiding potentially more environmentally

damaging alternatives such as wetland diking and filling. While the continental shelf is highly productive for marine fisheries, adverse impacts of dredged material disposal are generally not as severe as estuarine disposal. Ocean water over the shelf has greater dilution, mixing, and assimilative capacity. The continental shelf is not the scene of as many critical environmental processes (Allen and Hardy, 1980).

Ocean disposal will be conducted per the recommended plan during the spring and summer months when storm and wave conditions are more conducive to crossing the estuary bar. During this time of the year, summer current processes will predominate.

As dredged material falls to the bottom, finer materials will stay suspended for some time and be moved southward and offshore by prevailing currents. Once material reaches the bottom, it will become available to the northward-moving bottom current. Because summer wave effects are less noticeable, much of the material should remain in the vicinity of the disposal site and become more actively suspended and transported during the winter. Again, movement of the disposed material will be northward.

It is unlikely that any significant long-term change in bathymetry will occur from disposal, whether or not it is released at one point on the ocean surface or actively spread over a wider area. Winter storm-induced bottom disturbance will tend to disperse concentrations of sediment, spreading the material northward. Much of the material slated for ocean disposal is silty sand or sandy silt and, thus, very susceptible to resuspension and transport.

The Corps of Engineers (1981) has concluded from hydraulic studies, including recent seabed and surface drifter studies, that fine material disposed just off the bar (2.5 miles from the estuary mouth) will likely experience some movement onshore and back into the estuary. This effect appears to diminish with increased distance from the estuary mouth. Material disposed to the south of the estuary entrance will have a greater chance of reentering the estuary via northward, onshore currents. However, according to Corps studies, transport of the sand portion is energy-limited; therefore, increased quantities of sand would not be transported back into the estuary.

After extensive literature review, Allen and Hardy (1980) concluded that, in general, disposal of dredged material on the continental shelf should have little impact on water movement. They go on to conclude that impacts of disposal on the continental shelf water column should be minimal to nonexistent.

Significant releases of manganese and ammonia from the material can be expected during disposal. While normal dilution should reduce concentrations to harmless levels, ammonia could stimulate algal blooms already enriched by nutrient-laden, upwelled water. Plumb (1976), however, indicates no significant effect on algae will occur due to high rates of dilution. Any effect would probably be masked by the naturally occurring increase in productivity associated with upwelling during the months of ocean disposal.

Work by Smith et al. (1976) has shown that open-water disposal of Grays Harbor sediments within the estuary caused DO fluctuations of less magnitude than natural variations. DO levels at the estuary bottom were actually enriched and assumed to be the result of entrainment of oxygen-rich surface water. This may prove to be an important process in that oxygen has the desirable effect of oxidizing iron from the sediments to form iron oxides which flocculate and adsorb other dissolved substances, some of which are potentially toxic.

There are two primary sources of impact in the estuarine setting: dredging and disposal. Both will occur initially during the construction phase and annually for as long as the channel is maintained. Dredging by private interests will also occur both to align private berthing areas with the new channel configuration and to maintain those depths.

Weather conditions during a portion of the year, primarily the fall and winter months, make exit across the estuary bar hazardous and, in some cases, impossible. Therefore, in order to dredge and dispose year-round (an economic necessity, considering extra cost suffered through seasonal dredging interruption), some method of disposal making winter bar crossing unnecessary was needed. In the past, diking and filling was the most common method used for disposal. Because of the often severe impacts to fish and wildlife, focus shifted to open-water disposal. Open water near the mouth of the estuary has been used in the recent past for disposal of maintenance-dredged material and is considered by many to be less environmentally hazardous to fish and wildlife populations than diking and filling of wetland and upland habitat. During disposal, a mound of material should build up in each site. Current action will immediately begin to suspend and transport material away from one site. Material should eventually become suspended and transported by current action away from the site. Natural scouring action is prevalent in these deeper areas (USACE, 1981). Material will be transported both to the ocean and back into the estuary. Surface and seabed drifter studies conducted during the winter of 1981 by the Corps of Engineers (1981) indicate material movement back into the estuary decreases as the disposal site is moved seaward from the existing Pt. Chehalis site. The same study indicates that material reaching the bottom at the South Jetty site would be transported out to the ocean by strong predominant ebb currents, with minor amounts entering the estuary on the flood tide. Therefore, disposal sites needed, in addition to the South Jetty site, for project construction have been located seaward of the present site. The South Jetty site produced no in-estuary drifter recoveries. All recovered drifters were found on ocean beaches north of the estuary entrance. Model studies (Brogdon, 1972a-d) showed localized predominant ebb currents along the South Jetty and the drifter results tend to confirm that suspicion. Material deposited near the South Jetty would be expected to become resuspended and transported out of the estuary mouth, where it would enter the littoral drift system, the sand fraction being moved northward and onshore, and the silt fraction following density gradients offshore.

Some sands, however, may move onshore close to the harbor entrance on the ocean beach to the north and be transported back into the estuary around the North Jetty due to localized current action (USACE, Seattle District).

Winter wind does not appear to be a movement factor for surface currents at either site. Winter surface drifters were not found inside the estuary. Those recovered were found on ocean beaches to the north, indicating surface flow was the predominant transport factor during the study period. If wind were the major factor, drifters would have been discovered in the northern and eastern portions of the estuary driven by prevailing winds from the south and west.

Water column impacts attributable to dredging, real or suspected, take the form of nutrient release, increased suspended solids and turbidity, dissolved oxygen depletion, and release of contaminants (Allen and Hardy, 1980). The potential severity of these changes is a function of the degree of mixing and dilution at the disposal site. The recommended estuarine disposal areas are sites of turbulent activity, especially during the winter months when disposal there would take place. Strong ebb and flood currents scour the estuary bottom, while wind-induced wave action mixes and moves surface waters. Large quantities of both fresh and salt water pass through the area. Four well-mixed disposal sites in other areas of the U.S. were intensively monitored by the Dredged Material Research Program of the Corps of Engineers. The studies showed no adverse water column impacts occurred (Wright, 1978).

Sediments recommended for estuarine disposal are lower in contaminants than those slated for ocean disposal (AM Test, 1981). Of the total 9.9 million cubic yards of material slated for estuarine disposal, 8.6 million cubic yards consist of outer harbor coarser sandy material. These coarser materials have been selected for this disposal option for the purpose of mitigating contaminant release, minimizing turbidity, and reducing the transport of silts back into the estuary. Several studies have shown that there is not a significant release of toxicants into the water column during dredging (May, 1973b; Fulk et al., 1975; Chen et al., 1976; Lee et al., 1977; and Schroeder et al., 1977). Some common exceptions are ammonia, phosphorus, manganese, and iron. Most potential toxins are bound to finer-grained sediments and will thus tend to remain with the dredged material (Allen and Hardy, 1980).

Turbidity changes resulting from dredging should not be severe. Ambient turbidity levels during winter are already quite high due to high freshwater runoff and turbulent wave conditions. Suspended solids concentration from disposal of dredged material is usually not a serious problem (Hirsch et al., 1978) and is generally short-lived and of less magnitude than turbidity from natural occurrence (May, 1973; Markey and Putnam, 1976; and Schroeder et al., 1977). In all likelihood, project-induced natural turbidity occurrences in the winter will mask the project-induced turbidity to a great extent.

Nutrient release is often associated with disposal operations. Often, a significant release of ammonia and some orthophosphates will occur (Blom et al., 1976; Brannon et al., 1976; and Schroeder et al., 1977). Mixing and dilution should minimize this effect at the Grays Harbor sites.

Oxygen levels may become reduced near the bottom at the point of discharge (Stern and Stickel, 1978). Again, mixing, coupled with sediment of predominantly low organic content, should minimize this potential impact.

Analysis of post-construction hydrospheric changes relies primarily upon two studies: Corps of Engineers' physical model of Grays Harbor (Brogdon, 1972; Brogdon and Fisackerly, 1973; and Brogdon, 1975); and, more recently, an analysis of water characteristics and forecast of changes in water characteristics which might occur after project construction by Loehr and Collias (1981).

While the physical model does have inherent limitations (no consideration of meteorological conditions or of the distribution of biologically influenced DO), a great deal has been learned about changes in circulation and physical processes. Loehr and Collias (1981) sum up before- and after-project comparisons:

> Model studies of the dredged bottom configuration showed similar patterns of salinity, currents and dye dispersion (Brogdon, 1975). A comparison of the before and after data indicated that for low river flow the salinity regime remained essentially unchanged at all locations and all depths. For the mean river flow, the bottom water between Aberdeen and Cosmopolis was more saline in the after condition than in the before condition. However, the salinity values obtained for the low flow conditions were higher than those at the mean flow.
>
> Current measurements made for the post-dredge configuration indicated enhancement of the net seaward flow at the surface and the net landward flow at depth. Dye studies made in the post-dredge configuration emphasized the enhancement of the two-layer system within Grays Harbor. Dye injected near Cosmopolis at mean river flow was delayed about one day in transiting the estuary under post-dredge conditions with the delay occurring in the eastern half of Aberdeen Reach.

After an analysis of current velocity changes, increases in flushing time, enhancement of two-layer flow, increased ocean water intrusion, and upwelling, Loehr and Collias conclude new project channel configuration will have "no significant impact upon the water characteristics [of Grays Harbor]". It should be noted that their study was aimed at predicting only the significance of hydrospheric changes, not at resultant biological changes.

Changes in the mechanical properties of the sediments left exposed after dredging have rarely been monitored after dredging. This, however, was done in the case of hopper dredging by Slotta et al. (1973) in Coos Bay, Oregon, where a decrease was observed in median grain size at the dredge site after dredging. The authors believed the decrease was due to the exposure of fine subsurface sediments. Borings taken by the Corps of Engineers in Grays Harbor show a mix of sediment types similar to those presently found on the surface of the estuary bottom will be encountered at dredging depth (USACE, Seattle District). It is likely the newly exposed surface would soon resemble the existing one as sediment movement and deposition would work toward the present equilibrium under similar post-construction hydraulic conditions.

Allen and Hardy (1980) note a chronic turbidity condition often results after dredging. Sediments which settle into the new channel bottom become susceptible to resuspension by currents and wave action, with the channel acting as a trap for this fine, unfixed material (Taylor and Solomon, 1967). While this is probably true of the present channel, the problem may be exacerbated under the new configuration. Because of larger cross-sectional channel dimensions, overall current velocities will decrease, thereby decreasing the capacity to carry suspended loads. Maintenance quantities for the estuarine portion of the new channel dimensions will be 1.55 million cubic yards per year, an increase of 25 percent over present maintenance quantities. The net result of new channel construction may be a general increase in turbidity. However, in relation to present conditions, the increase would probably not be significant.

Predicted Socioeconomic Changes

Overall, the project will likely act as an economic stimulus to the Grays Harbor area. The forecast for recreation/tourism and fisheries should not change significantly from without-project conditions. However, the waterborne shipping activity of the transportation sector will likely experience moderate growth, stimulating the forest and forest products and services sectors of the local economy.

Project construction would allow Grays Harbor to better compete for a share of the wood products export market. Over time, this could lessen the severity and duration of lean market years, resulting in a more stable, productive local economy. This, in turn, could attract other commodities to the Grays Harbor export market perhaps, in turn, stimulating the road and rail segments of the transportation industry.

Actual economic growth is difficult to predict with accuracy; however, project construction provides conditions favorable for growth. The service industry would be expected to closely follow any increase in activity in the basic sectors of forest products and transportation.

The future of the recreation industry will change to the degree that the proposed project affects the ability of visitors to enjoy the natural setting, and the degree the project impacts the fish and wildlife which attract consumptive recreation. Project construction will likely not affect the recreation industry significantly. While some increases in the transportation industry might be foreseen, they would not impact recreation as they would probably be located near the inner harbor area, an area not presently noted for its scenic or aesthetic value. It is significant to note, however, that poorly planned or uncontrolled growth and sprawl of industry could affect recreational use in the plan area, a consequence local planners seem to be keenly aware of.

DISCUSSION OF PROJECT-RELATED FISH AND WILDLIFE IMPACTS

IMPACTS FROM PHYSICAL/CHEMICAL CHANGES

Estuarine

During initial construction, 75 percent or more of the benthic organisms will be removed from the dredging area (USACE, 1975). Dungeness crabs will be

entrained with use of the hopper dredging equipment. Under the present scheduling and equipment features, an estimated 2 million crabs (of the entire range of age classes) will be killed during construction. Very few will be entrained in reaches where clamshell dredges are used (Armstrong et al., 1982). Dredging schedules and dredge equipment type have been selected to avoid known concentrations of crabs at particular times in particular reaches in an effort to reduce impacts to this commercially important species.

Benthos in the artificially dredged channel is presently in a periodically disturbed state because of annual maintenance dredging activity. New maintenance activity will produce identical, albeit more extensive, disturbance.

Spanning a 2-year construction period, the Recommended Plan will leave much of the channel undisturbed at any particular point in time. Undisturbed benthic assemblages and recently recolonized areas will be distributed throughout the channel, available to act as "seed" areas for recolonization of adjacent areas.

Recolonization of the benthos is an extremely important point when considering the significance of construction impacts. Morton (1977) points out that natural population fluctuations caused by seasonal migration or rapid repopulation of the affected benthos can mask the immediate effects of dredging. In Coos Bay, Oregon, Slotta et al. (1973) reported that recolonization of benthic infauna to former abundance levels occurred within 2 weeks of dredging. Other studies report the same recolonization occurring between 2 weeks to 4 months (Chesapeake Biological Laboratory, 1970; Taylor, undated; USACE, 1975). Bottom modification was found by Harrison et al. (1964) to only affect infaunal populations temporarily. Affected areas were soon resettled in that particular portion of the lower Chesapeake Bay.

Pfitzenmeyer (in Chesapeake Biological Laboratory, 1970) reported that in the dredged channel, benthic populations remained lower in numbers, but of the same order of magnitude as before the dredging. Curiously, Pfitzenmeyer reported that a 50 percent increase in biomass was observed in the deeper channels soon after dredging, the result of an increase in the numbers of a polycheate, Scolecolepides verides.

The potential for rapid and complete repopulation of the channel benthos to pre-project levels appears to be very good. Results of the aforementioned studies, combined with studies showing no significant change in water quality and sediment distribution, lead us to believe no significant long-term impact to the benthos will occur in channel habitat outside of the direct destruction of crabs through entrainment.

Likewise, assuming that the Corps' prediction of the fate of material disposed of in naturally scoured channel habitat is correct, disposal should not significantly impact fish and wildlife.

As previously described, these deeper, naturally scoured areas proposed as disposal sites are disphotic and subjected to strong ebb currents. Sediments in this area consist of coarse sand. Study by the Corps of Engineers

indicates immediate and active erosion of disposed material will occur in these highly disturbed, high energy areas. As deposition builds in excess of erosion, current velocities should increase as a result of a decrease in cross-sectional channel area, thus enhancing erosive forces as the site is filled. Eventually, the sites are expected to return to pre-project depths. Because of the high degree of surface wave-induced mixing and high tidal flushing, acute water quality effects should not pose a significant impact to flora and fauna of the water column. Several studies elsewhere in the country, including field observations during and immediately after disposal, indicate no significant decrease in primary production as a result of open-water disposal (Chesapeake Biological Laboratory, 1970; Ingle, 1952; Odum and Wilson, 1962; Taylor and Salomon, 1967). Morton (1977) suggests the effect of reduced light penetration as a result of disposal may be compensated to a degree "by the enrichment provided by nutrients released when bottom sediments are resuspended".

The coarser, heavier, sandy material generally proposed for disposal in the open water of the estuary further reduces any chance of significant impact This material is cleaner and generally coarser, and should settle faster, making less material available for transport back into the estuary via flood tide and wind-induced surface currents.

Post-construction channel benthic communities should be, through recolonization, very similar to present conditions.

Approximately 210 acres of estuarine subtidal mud and sandflat which now lies adjacent to the present channel will be dredged. This habitat type essentially forms the margin of the existing channel and would be transformed by dredging into new channel habitat. Of this 210 acres, less than 4 acres is shallow (above -10 feet MLLW). The rest forms a habitat of transitional depth down to the depth of the present channel habitat.

Dredging construction effects are identical to those described for existing channel habitat; removal of benthic organisms, entrainment of slow-moving nekton, and temporary water quality perturbations.

Water quality changes during dredging are short-lived and should be of insignificant impact to nearby flora and fauna.

The question of significant net loss must focus on the relative value between pre-project subtidal flat and post-project channel habitat. Is the existing habitat significantly more biologically productive than the artificially created habitat that will be created?

In deeper areas, new channel habitat once recolonized (see preceding section) should be similar to the former assemblage. Newly dredged subtidal flats will still be bounded by the former habitat type, sloping gently downward to deeper channel bottom. Organisms from subtidal flats left undisturbed would be expected to recolonize upper portions of the new channel side slopes, while fauna more adapted to deeper habitat should become established in lower portions of the side slope.

Given the relatively small amount of areal exchange from one habitat type to another and the resulting conditions previously described, we do not feel any long-term significant impacts will occur to fish and wildlife through dredging of deeper subtidal mud and sandflats.

A different opinion must be rendered in the case of the approximately 4 acres of shallow subtidal habitat (less than -10 feet MLLW) destroyed and permanently transformed to channel habitat. This change would result in a significant loss of habitat productivity, a habitat of very high value to commercial fish species (Simenstad and Eggers, 1981). While this habitat type is not rare in Grays Harbor, it is very limited in areas where the shallows will be deepened. We consider this change in habitat value to be a significant impact to fish and wildlife and mitigation is recommended to compensate for this loss.

Eelgrass habitat is extensive within the Grays Harbor Estuary and very important to a wide variety of organisms ranging from epiphytes to black brant.

Eelgrass habitat will not be directly altered through project construction. Simenstad and Eggers (1981) could not locate eelgrass even in low abundance in the path of the proposed channel.

Productive eelgrass requires a complex set of fairly specific habitat variables. A list of these variables and range of values conducive to eelgrass growth is provided in Table 4. A significant change in any of these parameters could point to a loss of eelgrass habitat. It does not appear, from our discussion of physical/chemical change, that any significant change in eelgrass habitat extent or productivity will occur through channel construction or operation and maintenance.

The Corps of Engineers has determined that no intertidal or saltmarsh habitat will be directly affected by dredging. Neither should there be any adverse indirect effects.

Oceanic

Biological impacts due to dredging of the Outer Bar reach are similar to those experienced in estuarine channel areas. The habitat is very similar to present outer harbor channel areas except maintenance dredging is presently not required. This area is, however, a dynamic zone of sediment movement and instability.

Benthic recolonization should occur rapidly, as discussed for channel habitat, and the difference between pre- and post project habitats should be insignificant.

Discussion of the biological impacts caused by dredged material disposal is, at this point, limited to a very generalized one. Because an appropriate site will not be selected until CP&E, only a very basic forecast can be developed, with major assumptions still untested. The following analysis is therefore based predominantly upon findings reported from studies conducted in areas other than Grays Harbor. This information is the best available at this time.

Table 4. Numerical characteristics of eelgrass habitat factors (from Phillips, 1974)

HABITAT FACTOR	VEGETATIVE GROWTH	PLANT ACTIVITY FLOWERING STATE	SEED GERMINATION
TEMPERATURE			
Range	0 - 40.5°C	-----	-----
Optimum	10 - 20°C	15 - 20°C (8-9°C in Puget Sound)	5 - 10°C[a]
SALINITY			
Range	Fresh water - 42 °/oo	-----	-----
Optimum	10 - 30 °/oo	Same as optimum	[illegible] 5 - 9.1 °/oo
DEPTH-LIGHT[b]			
Range	1.8 meters above MLLW to 30 meters deep	-----	-----
Optimum	MLLW - 6.6 m below MLLW (11 m at high tide)	Effect unknown	No effect
SUBSTRATE			
Range	Pure firm sand to pure soft mud	-----	-----
Optimum	Mixed sand and mud	No effect	No effect
pH	7.3 - 9.0	Effect unknown	Effect unknown
WATER MOTION			
Range	Waves to stagnant water	-----	-----
Optimum	Little wave action. Gentle currents to 3.5 knots	Effect unknown	Effect unknown

[a] Arasaki (1950 A) found no correlation with temperature. Most reports list highest incidence of germination occurring in February and March.

[b] Due to naturally high turbidity, lowest depth range in Grays Harbor is limited at approximately -3 feet MLLW.

Continental shelf areas are known to be highly productive areas for marine fisheries. However, compared to estuaries, continental shelf habitat is not the scene of as many critical physical/chemical and biological processes. Many changes which might occur in an estuary as a result of disposal of dredged material will be less severe or nonexistent on the continental shelf (Allen and Hardy, 1980).

Water column changes, as previously discussed, are expected to be insignificant and of very short duration. Work by Plumb (1976) indicates that stimulatory or inhibitory materials released from dredged sediments do not have a significant effect on algae when the rate of dilution in continental shelf water columns is considered.

Allen and Hardy (1980) determined from a survey of the literature that continental shelf disposal should "pose no problems to concentrations or migrations of fishes". Saila et al. (1972) expressed the opinion that most marine organisms can withstand exposure to even high concentrations of suspended solids for short periods of time.

Potential impacts to benthic faunal assemblages include smothering and burial of organisms, contaminant uptake, and physical changes in bathymetry. The question of contaminant uptake has not been resolved as of this writing. Procedural and funding problems suffered by the Corps of Engineers have delayed even preliminary findings until some time after the completion of this document. In the meantime, because of the relatively low levels of contaminants assayed in the sediments to be dredged (AM Test, 1981) and the large assimilative capacity of the oceanic environment, we will assume results of bioassays will not preclude the ocean disposal alternative nor indicate a problem to fish and wildlife species. Any deviation from this outcome will require reconsideration of potential impacts by the Fish and Wildlife Service.

Direct burial of the benthos is the most obvious effect of disposal. Alternative disposal techhniques, such as widespread versus concentrated, have not been discussed; therefore, it cannot be said with certainty what the effect will be. Some sessile organisms will be killed outright, while other mobile forms may migrate to the surface through the new sediments as they are deposited.

Pratt (1979) monitored 10 disposal sites on the New England continental shelf and noted the most deleterious effects of disposal have been obstruction of trawling activity and burial of ocean quahogs.

Some impacts appear to be beneficial. First (1969) and Valenti and Peters (1977) noted significantly greater assemblages of dimersal fish and lobsters in the historic Eatons Neck, Long Island Sound, disposal site.

In a study by Richardson et al. (1977), a significant increase in diversity, evenness values, and biomass was noted at dredged material disposal areas off the mouth of the Columbia River. It was also found that stations affected by dredged material but not directly buried exhibited intermediate values.

Sediment transport processes will tend to disperse the discharged dredged material, eventually causing the material to come into contact with a large surface area. Silts should eventually move offshore with the existing silt regime, while cleaner, coarser sands would be expected to experience net movement northward and onshore.

It is the opinion of the Service that within an 8-mile radius offshore of Grays Harbor, there is a high probability that a disposal site may be found which will not produce adverse impacts of sufficient magnitude so as to require extensive compensation for unavoidable loss. However, even though the Service agrees that pursuit of the Recommended Plan is feasible from the standpoint of ocean disposal, additional studies are recommended for CP&E in order to best select a particular site or sites which will further refine construction plans to minimize loss of fish and wildlife.

IMPACTS FROM SOCIOECONOMIC CHANGES

This section is included to explain how potential project-related changes in the socioeconomic environment could affect fish and wildlife habitat. It is not meant as justification for any recommended mitigation. Socioeconomic changes, in this case, are difficult to predict and if significant changes do occur, planning and regulation, as well as environmental safeguards, are best left to individual situations as they arise in the future. Therefore, this section serves only to illustrate potential indirect impacts of socioeconomic change.

Our analysis of project-induced socioeconomic changes shows the possibility of an increase in three sectors; forest products, transportation, and services. The possibility of an increase in these areas is greatly enhanced through improvements to the navigation channel, but is by no means guaranteed. Fisheries and recreation/tourism are not expected to change significantly due to project construction.

In the case of Grays Harbor, the transportation industry can affect fish and wildlife habitat through construction and maintenance of export facilities, generation of toxic wastes, or spilling of fuel from vehicles and ships. Other effects include disturbance of natural areas by noise and visual quality changes, the preemption of fish and wildlife habitat for transportation facilities, and the use or development of areas made possible through increased human access (Proctor et al., 1980).

Both truck and rail transportation could be candidates for growth through attraction of new commodity inflow, and can affect fish and wildlife habitat through direct loss, increased runoff and sedimentation rates, and accidental spills. Terminals and processing centers aimed at water-borne export require flat, nearshore land, land which in the past was usually obtained in Grays Harbor through the diking and filling of wetlands. Paved surfaces would increase runoff rates and increase the potential for non-point source pollution. Depending upon the activities pursued at these terminals, chemical and noise pollution could degrade nearby habitat.

The forest and forest products industry affects natural systems through logging (sedimentation, habitat destruction and alteration, water quality), transportation (sedimentation, loss of habitat, blocks to salmonid migration, oil and grease runoff), and processing (loss of habitat, effluent and other wastes, accidental spills).

Increases in the services industry can have many adverse effects on habitat. It is much more difficult to mitigate the loss of habitat value caused by this sector because single events are seemingly insignificant until their cumulative effect is noticed. Loss of value includes destruction of habitat, pollution through stormwater runoff, increased sedimentation via construction practices, raw or treated sewage effluent, and increased human access into surrounding undisturbed habitat.

MITIGATION

Guidance for this section of the report is provided under the U.S. Fish and Wildlife Service Mitigation Policy (Federal Register 46:15, January 23, 1981). The primary focus of the policy is on habitat and its value. Population estimates are considered by many to be unreliable indicators for evaluation of impacts to fish and wildlife. Sampling errors, cyclic population fluctuations, and the lack of time series data all contribute to the difficulty of assessing fish and wildlife impact through population estimation.

The Grays Harbor Estuary is no exception to this difficulty. The Service feels that habitat value, judged by measurement against importance to evaluation species, scarcity, and replacability, is the best way to calculate and, thus, mitigate unavoidable losses. Use of population losses in mitigation formulation is, however, by no means precluded. In many cases, populations of organisms are affected outright, while habitat is not. In Grays Harbor, crab entrainment in dredging equipment and subsequent mortality is a case in point.

Loss of 4 acres of shallow subtidal habitat represents significant impact for which mitigation is recommended. This habitat, located in the inner harbor area where it has become very rare, falls into a Resource Category 2 designation under the Mitigation Policy in that the habitat to be impacted is of high value for evaluation species (salmonids and English sole) and is becoming scarce on a national basis. We consider salmonids and English sole to satisfy criteria for selection as evaluation species in that they represent a high resource value to humans.

Many studies have found this type of habitat to be extremely valuable to salmonids. These include: Congleton and Smith (1976); Dunford (1975); Gerke and Kaczynski (1972); Healey (1979); Mason (1974); Merrell and Koski (1978); Reimers (1971); Sibert et al. (1977); Levy et al. (1979); Simenstad et al. (1980); Meyer et al. (1980); and Simenstad and Eggers (1981).

We recommend this loss of habitat be compensated in the following manner:

Acquisition of at least 4 acres of presently altered habitat in the inner harbor portion of the estuary. (That would be east of a straight line drawn

between Point New on the north shore and Ocosta on the south). Altered habitat is defined as habitat which, through human alteration such as diking and filling, has been taken out of production in the estuarine ecosystem.

We recommend that the acquired habitat be physically transformed into shallow subtidal habitat, thus restoring for the life of the project habitat values lost in the inner estuary by project construction.

Exact treatment details and specifications should be determined during the CP&E phase. Site selection would be premature at this stage of the planning process. General treatment features might include substrate alteration to rid the area of polluted sediments, depth alteration, shoreline adjustment, and so on.

The destruction of Dungeness crabs in Grays Harbor due to dredging is another significant loss for which mitigation is recommended. Crab mortality due to construction dredging has been estimated to be 2 million crabs representing all age classes over the [illegible]-year construction period (Armstrong et al., 1982). Out of an estimated mean summer estuarine population of 28.4 million, this represents a significant reduction, with potential natural system and economic ramifications.

There is good reason to believe that crab mortality can be lessened, perhaps appreciably, through modifications to the hopper dredging equipment (Armstrong et al., 1982).

The Service has recommended that further investigation into methods of avoiding hopper dredge entrainment be conducted during the CP&E phase. It is our hope that mitigation in the form of impact avoidance will prove successful.

If mechanical modifications prove unsuccessful or impractical, further changes in dredge type use and scheduling are recommended to reduce crab mortality. If changes of this type prove to be inefficient or economically impractical, the Service recommends mitigation in the form of compensation be performed. This might take the form of enhancing crab survival rates in Grays Harbor, devoting funds to additional study of crab mortality, or some form of habitat treatment. It is the opinion of the Service that impacts to the Grays Harbor Dungeness crab population can be adequately mitigated through one or more of the suggested methods.

FURTHER STUDIES RECOMMENDED FOR CONTINUING PLANNING AND ENGINEERING PHASE

Several studies are recommended for the purpose of further refining formulation of the Recommended Plan, assuming the project is authorized, during Continuing Planning and Engineering (CP&E). Knowledge gained through completion of these studies will assist in development of sound construction designs which will further avoid and minimize biological losses. Analysis of biological impact has, to date, been based on a level of detail sufficient to judge feasibility from an environmental standpoint. Much of the forecast has been based on assumptions with a high probability of validity; however, the test of that validity remains outstanding.

We recommend the following studies:

1. Further analysis of sediment movement after disposal at open-water sites near the estuary mouth. A determination of the rate of erosion and fate of material during different times of the year and tidal cycles so as to simulate events occurring through construction are prime objectives. Grain size and degree of consolidation should be considered variables. Maintenance materials presently disposed in open water under continuing authority would serve nicely as a source of material needed to perform the investigation.

2. Development and analysis of various modifications of hopper dredging equipment designed to avoid crab entrainment. Working with experts in the field, the Corps should develop and test prototype modifications to judge their effectiveness at clearing crabs away from the dredging heads. Devices judged to be effective at significantly avoiding crab entrainment would then be made available and used during construction and maintenance activities. These devices may take the form of lights, warning stimulus, irritants, physical disturbance, or a combination of these or other techniques.

3. Refinement of peak crab abundance estimates and period of habitat use within the new channel alignment. Further refinements in dredging sequence, timing, or technique would be the expected outcome in an effort to decrease crab mortality and reduce potential economic loss to crab fisheries.

4. Conduct, as previously agreed, studies necessary for selection and designation of ocean disposal site(s). These include chemical, physical, and biological studies to aid in determining the most biologically sound location and method of disposal while avoiding economic dislocation of fishermen and other ocean users.

ENHANCEMENT

Enhancement of fish and wildlife resources (and habitat) is considered by the Corps of Engineers to be an objective of the Corps Water Resource Program. Enhancement measures are to be considered in planning, design, construction, operation, and maintenance of projects. Stated methods may include, but are not limited to, actions to preserve or enhance habitat; maintain or enhance water quality; improve streamflow; and preserve or create wetlands. The following section is included to assist the Corps of Engineers and others in future planning of potential enhancement features.

Many opportunities for fish and wildlife enhancement exist in the Grays Harbor area. Habitat value has been degraded over the last century and could potentially, through judicious use of structural and nonstructural means, be increased for the benefit of fish and wildlife and that portion of our nation's economy which depends upon that natural resource. Suggested enhancement measures are:

1. Placement of perching sites for raptors in the form of pilings distributed in the North and South Bay portions of the estuary. The lack of perch sites in these wide expanses of intertidal and shallow subtidal habitat may be a limiting factor to raptors which depend on birds and fish which rest and forage in these habitats (Bottorff, personal communication). Raptors, such as the peregrine falcon, expend considerable energy in pursuit of prey and are limited in their extent of pursuit if nearby resting and feeding sites are not present. Few such perch sites are presently available and their existence could enhance the beleaguered populations of raptors in the plan area.

2. Land acquisition and treatment in excess of that previously recommended for mitigation would enhance the ability of the estuary to provide rearing and feeding habitat for juvenile salmonids. Depending upon site location, treatment measures, and acquisition cost, increases in juvenile salmonid survival and contribution to fisheries over the project life could easily outweigh costs of enhancement.

3. Poor logging practices and other human disturbance have degraded natural spawning and rearing habitat used by salmonids. Small creeks and streams which empty into the estuary are, in some cases, clogged with debris which block or hinder migration; silt now covers former spawning gravel, streamside vegetation has been destroyed, culverts designed without regard for salmonid migration have been installed during past road construction.

   Through appropriate funding, removal of these barriers to salmonid production would provide increased natural production of important fish species. Once the problems are corrected, little further effort needs to be expended while nature provides increased production. The economic benefits of this production could easily outweigh the costs of restoration.

THREATENED AND ENDANGERED SPECIES

Pursuant to the Endangered Species Act of 1973, as amended, this agency notified the U.S. Army Corps of Engineers on December 17, 1980, as requested, that the bald eagle (Haliaeetus leucocephalus) and peregrine falcon (Falco peregrinus) occur within the plan area. These species are listed on the Federal List of Endangered and Threatened Wildlife and Plants. The Corps of Engineers responded with preparation of a biological assessment dated October 6, 1981, evaluating the possible effects of the Grays Harbor and Chehalis River Improvements to Navigation Project on those species. The biological assessment concluded the project would have no effect, with which the Service concurred. However, as noted in our response dated November 25, 1981 (ref. #1-3-82-I-19), the conclusions of no effect are based on specific construction and maintenance features. As changes are incorporated into a more solidified plan, further assessments should be conducted and presented. In addition, the California brown pelican (Pelecanus occidentalis californianus) was added to the species list for this project (letter to Chief, Engineering Section, dated November 25, 1981). The Corps of Engineers responded with preparation of an additional biological assessment dated

February 11, 1982, evaluating project effects on the California brown pelican. The assessment concluded the project would have no effect, with which the Service concurred in a response dated March 18, 1982.

REFERENCES

Allen, K. O., and Hardy, J. W. 1980. Impacts of navigational dredging on fish and wildlife: A literature review. U.S. Fish and Wildlife Service, Biological Services Program. FWS/OBS-80/07. 81 pp.

AM Test, Inc. 1981. Chemical testing of sediments in Grays Harbor, Washington. U.S. Army Corps of Engineers, Seattle District. 112 pp.

Armstrong, D. A., Stevens, B G., and Homan, J. C. 1982. Distribution and abundance of Dungeness crab and crangon shrimp and dredging-related mortality of invertebrates and fish in Grays Harbor, Washington. U.S. Army Corps of Engineers, Seattle District. 349 pp.

Blom, B. E., Jenkins, T S., Leggett, D. C., and Murrmann, R. P. 1976. Effects of sediment organic matter on migration of various chemical constituents during disposal of dredged material. U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire. Published by U.S. Army Eng. Waterways Exp. Stn., Vicksburg, Mississippi. Contract Rep. D-76-7.

Bottorff, J. Endangered Species Team Leader, U.S. Fish and Wildlife Service, Olympia, Washington. Personal communication.

Brannon, J. M., Engler, R. M., Rose, J. R., Hunt, P. G., et al. 1976. Selective analytical partitioning of sediments to evaluate potential mobility of chemical constituents during dredging and disposal operations. U.S. Army Eng. Waterways Exp. Stn., Vicksburg, Mississippi. Tech. Rep. D-76-7.

Brogdon, N. J., Jr. 1972a. Grays Harbor Estuary, Washington Report 1, Verification and base tests, hydraulic model investigation. U.S. Army Eng. Waterways Exp. St. Tech. Rep. H-72-2. 25 pp. + 2 tables, 25 photos, and 211 plates.

Brogdon, N. J., Jr. 1972b. Grays Harbor Estuary, Washington Report 2, North Jetty study, hydraulic model investigation. U.S. Army Eng. Waterways Exp. Stn. Tech. Rep. H-72-2. 16 pp. + 4 tables, 5 photos, and 122 plates.

Brogdon, N. J., Jr. 1972c. Grays Harbor Estuary, Washington Report 3, Westport small-boat basin study, hydraulic model investigation. U.S. Army Eng. Waterways Exp. Stn. Tech. Rep. H-72-2. 13 pp. + 1 table, 22 photos, and 116 plates.

Brogdon, N. J., Jr. 1972d. Grays Harbor Estuary, Washington Report 4, South Jetty study, hydraulic model investigation. U.S. Army Eng. Waterways Exp. Stn. Tech. Rep. H-72-2. 21 pp. + 4 tables, 16 photos, and 260 plates.

Brogdon, N. J., Jr. and Fisackerly, G. M. 1973. Grays Harbor Estuary, Washington Report 1, Verification and base tests. Appendix A: Supplementary base test data, hydraulic model investigation. U.S. Army Eng. Waterways Exp. Stn. Tech. Rep. H-72-2. 5 pp. + 4 tables and 309 plates.

Brogdon, N. J., Jr. 1975. Grays Harbor Estuary, Washington Report 5, maintenance studies of 35-foot deep (MSL) navigation channel, hydraulic model investigation. U.S. Army Eng. Waterways Exp. Stn. Tech. Rep. H-72-2. 65 pp. + 26 tables, 20 photos, and 96 plates.

Chen, K. Y., Gipta, S. K., Sycip, A. Z., Lu, J. C. S., et al. 1976. Research study on the effect of dispersion, settling, and resedimentation on migration of chemical constituents during open-water disposal of dredged materials. Univ. Southern California, Los Angeles. Published by U.S. Army Eng. Waterways Exp. Stn., Vicksburg, Mississippi. Contract Rep. D-76-1.

Chesapeake Biological Laboratory. 1970. Gross physical and biological effects of overboard spoil disposal in upper Chesapeake Bay. NRI (Nat. Res. Inst.) Spec. Rep. 3, University of Maryland, Solomons. 66 pp.

Congleton, J. L., and Smith, J. E. 1976. Interactions between juvenile salmon and benthic invertebrates in the Skagit salt marsh. IN First Pacific Northwest Tech. Workshop, Astoria, Oregon, October 13-15, 1976. Eds. C. A. Simenstad and S. J. Lipovsky. 31-35.

Demory, R. L., and Robinson, J. G. 1973. Resources surveys on the continental shelf off Oregon, annual report, July 1, 1972, to June 30, 1973. National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, and Fish Commission of Oregon, Portland, Oregon.

Dugan, P. Grays Harbor Regional Planning Commission, Personal communication.

Dunford, W. E. 1075. Space and food utilization by salmonids in marsh habitats of the Fraser River estuary. M.S. thesis, University of British Columbia. 81 pp.

First, M. W. 1969. Waste incineration at sea and ocean disposal of non-floating residues. Sixty-second annual meeting of the Air Pollution Control Association, June 8-12, 1969. New York City. Pap. 69-33.

Fulk, P., Cruver, D., and Wullschleger, R. 1975. Laboratory study of the release of pesticide and PCB materials to the water column during dredging and disposal operations. Envirex, Inc., Milwaukee, Wisconsin. Published by U.S. Army Eng. Waterways Exp. Stn., Vicksburg, Mississippi. Contract Rep. D-75-6.

Gerke, R. J. and Kaczynski, V. W. 1972. Food of juvenile pink and chum salmon in Puget Sound, Washington. Wash. Dept. of Fish., Tech. Rep. 10. 27 pp.

Grays Harbor Regional Planning Commission. 1981. Overall economic development program for Grays Harbor County, Washington, for 1981: Annual progress report. 46 pp.

Harrison, W., Lynch, M. P., and Altschaeffl, A. G. 1964. Sediments of lower Chesapeake Bay, with emphasis on mass properties. J. Sediment. Petrol. 34(4):727-755.

Healey, M. C. 1979. Detritus and juvenile salmon production in the Nanaimo Estuary: I. Production and feeding rates of juvenile chum salmon (Oncorhynchus keta). Journal Fish. Res. Board, Canada. 36:488-496.

Herman, S. and Bulger, J. 1981. The distribution and abundance of shorebirds during the 1981 spring migration at Grays Harbor, Washington. U.S. Army Corps of Engineers.

Hirsch, N. D., DiSalvo, L. H., and Peddicord, R. 1978. Effects of dredging and disposal on aquatic organisms. Univ. California, Naval Bioscience Lab., Oakland. Published by U.S. Army Eng. Waterways Exp. Stn., Vicksburg, Mississippi. Tech. Rep. DS-78-5.

Ingle, R. M. 1952. Studies on the effect of dredging operations upon fish and shellfish. Fla. State Board Conserv., St. Petersburg, Florida, Tech. Ser. No. 5. 26 pp.

Kalinowski, S. A., Martin, R. C., and Cooper, L. D. 1982. Wildlife studies at proposed disposal sites in Grays Harbor, Washington. U.S. Army Corps of Engineers, Seattle District.

Kuhn, G. A., Lehr, R. D., Bricklet, J. A., Zelenka, J. E., Sullivan, A. M., York, M. K., and Ogborn, D. R. Special economic study team of the Oregon Coastal Conservation and Development Commission. 1974. Economic analysis and profile of the Oregon coastal zone. Pacific Northwest Regional Commission, Vancouver, Washington, and State of Oregon, Department of Economic Development, Salem, Oregon. pp. A1-J20.

Lee, C. F., Bandyopadhyay, P., Butler, J., Homer, D. H., et al. 1977. Aquatic disposal field investigations, Galveston, Texas, offshore disposal site; Appendix B: Investigation of water-quality parameters and physiochemical parameters. Univ. Texas at Dallas. Published by U.S. Army Eng. Waterways Exp. Stn., Vicksburg, Mississippi. Tech. Rep. D-7720.

Levy, D. A., Northcote, T. G., and Birch, G. J. 1979. Juvenile salmon utilization of tidal channels in the Fraser Estuary, British Columbia. Westwater Res. Tech. Rep. No. 23, November 1979. University of British Columbia. 70 pp.

Loehr, L. C. and Collias, E. E. 1981. A review of water characteristics of Grays Harbor 1938-1979 and an evaluation of possible effects of the widening and deepening project upon present water characteristics. U.S. Army Corps of Engineers, Seattle District. 97 pp.

Lough, R. G. 1974. Dynamics of crab larvae (Anomura, Brachyura) off the central Oregon coast, 1969-1970. Ph.D. thesis. Oregon State University, Corvallis, Oregon. 818 pp. (Abstracted in: (1) Sea Grant Publ. ORESU-XI-74-003, (2) Dissert Abstr. Int. Sec. B, 35/7:3478.)

Markey, J. W., and Putnam, H. O. 1976. A study of the effects of maintenance dredging on selected ecological parameters in the Gulfport Ship Channel, Gulfport, Mississippi. Pages 821-832 IN Proceedings of the Specialty Conference, Dredging and its Environmental Effects, 26-28 January 1976, Mobile, Alabama. American Society Civil Engineers, New York.

Mason, J. C. 1974. Behavioral ecology of chum salmon fry in a small estuary. Journal Fish. Res. Board Can. 31(1):63.

May, E. F. 1973b. Environmental effects of hydraulic dredging in estuaries. Ala. Mar. Res. Bull. 9:1-85.

McGary, N. B. 1971. An atlas of the Columbia River effluent and its distribution at sea. Special Report No. 47, U.S. Atomic Energy Commission Contract (AT945-1)-2225. Department of Oceanography, University of Washington, Seattle, Washington. 57 pp.

McRoy, C. P. 1966. The standing stock and ecology of eelgrass, Zostera marina, Izembek Lagoon, Alaska. M.S. thesis. Univ. of Washington, Seattle. 138 pp.

Merrell, T. R., and Koski, K. V. 1978. The role of coastal wetlands on habitat for salmon in Alaska and the Pacific Northwest. Presented at Natl. Wetlands Symposium, Lake Buena Vista, Florida.

Meyer, J. H., Pearce, T. A., and Patlan, S. B. 1980. Distribution and food habits of juvenile salmonids in the Duwamish Estuary, Washington. U.S. Fish and Wildlife Service, prepared for U.S. Army Corps of Engineers. 42 pp.

Miller, G. H. 1977. Eelgrass distribution, density, leaf length, and standing stock in Grays Harbor, 1977. U.S. Army Corps of Engineers, Seattle District. DACW 67-77-M-1240. 22 pp.

Morton, J. W. 1977. Ecological effects of dredging and dredge spoil disposal. Technical papers of the U.S. Fish and Wildlife Service; 94. From the author's thesis (M.S.), Cornell University, 1976. 33 pp.

Nittrouer, C. A. 1978. The process of detrital sediment accumulation in a continental shelf environment: An examination of the Washington continental shelf. Ph.D thesis, Department of Oceanography, University of Washington, Seattle. 243 pp.

Nosho, T., Tomokiyo, R., and Ward, D. 1980. Commercial fish landings in Washington State ports, 1971-1979. Sea Grant Technical Report WSG-80-4. 21 pp.

Oceanographic Institute of Washington. 1977. A summary of knowledge of the Oregon and Washington coastal zone and offshore areas. Vols. I, II, and III. Oceanographic Institute of Washington for the Bureau of Land Management, U.S. Department of the Interior. Var. pp.

Odum, H. T., and Wilson, R. F. 1962. Further studies on reaeration and metabolism of Texas bays, 1958-1960. Publ. Inst. Mar. Sci., University of Texas. 8:23-55.

Oregon State University. 1971. Oceanography of the nearshore coastal waters of the Pacific Northwest relating to possible pollution. Prepared for the U.S. Environmental Protection Agency, Water Quality Office. Grant No. 16080 EOK. Oregon State University, Corvallis, Oregon. Vol. 1, 615 pp., Vol. 2, 744 pp.

Plumb, R. H., Jr. 1976. A bioassay dilution technique to assess the significance of dredged material disposal. U.S. Army Eng. Waterways Exp. Stn., Vicksburg, Mississippi. Misc. Pap. D-76-6.

Pratt, S. D. 1979. Fisheries and dredged material in New England. University of Rhode Island, Kingston. Presented at the Northeast Fish and Wildlife Conference, April 1-4, 1979. Providence, Rhode Island. (unpublished)

Proctor, C. M. et al. 1980. An ecological characterization of the Pacific Northwest coastal region. 5 vol. U.S. Fish and Wildlife Service, Biological Services Program. FWS/OBS-79/11 through 79/15.

Reimers, P. E. 1971. The length of residence of juvenile fall chinook salmon in Sixes River, Oregon. Ph.D. thesis, Oregon State University. 99 pp.

Richardson, M. D., et al. 1977. Aquatic disposal field investigations, Columbia River disposal site, Oregon; Appendix C: The effects of dredged material on benthic assemblages, Technical Report D-77-30. U.S. Army Eng. Waterways Exp. Stn., Vicksburg, Mississippi.

Saila, S. B., Pratt, S. D., and Polgar, T. T. 1972. Dredge spoil disposal in Rhode Island Sound. University of Rhode Island Mar. Tech. Rep. 2. 48 pp.

Scheidegger, J. F., and Phipps, J. B. 1976. Dispersal patterns of sands in Grays Harbor Estuary, Washington. IN Journal of Sedimentary Petrology, 46(1):163-166.

Schmisseur, W. E., and Boodt, W. 1975. Oregon coastal area, including south-western Oregon counties: Economic survey and analysis, Pacific Northwest River Basins Commission, Vancouver, Washington. 123 pp.

Schroeder, W. L., Williamson, K. J., Hudspeth, R. T., Farness, D. H. K., et al. 1977. Dredging in estuaries: Guide for review of environmental impact statements. Oregon State Univ., Corvallis. Performed for the National Science Foundation, Washington, D.C.

Sibert, J., Brown, T. J., Healey, M. C., Kask, B. A., and Naiman, R. J. 1977. Detritus-based food webs: Exploitation by juvenile chum salmon (Oncorhynchus keta). Science, May 1977. pp. 649-650.

Simenstad, C. A., Kinney, W. J., Parker, S. S., Salo, E. O., Cordell, J. R., and Buechner, H. 1980. Prey community structure and trophic ecology of outmigrating juvenile chum and pink salmon in Hood Canal, Washington: A synthesis of three years' studies, 1977-1979. Fish. Res. Inst., University of Washington, Rept. No. 8026. 113 pp.

Simenstad, C. A., Eggers, D. M. 1981. Juvenile salmonid and baitfish distribution, abundance, and prey resources in selected areas of Grays Harbor, Washington. U.S. Army Corps of Engineers, Seattle District. DACW 67-80-C-0102. 205 pp.

Slotta, L. S., Sollitt, C. K., Bella, D. A., Hancock, D. R., McCaule, J. E., and Parr, R. 1973. Effects of hopper dredging and in-channel spoiling in Coos Bay, Oregon. Oregon State University, Corvallis. 141 pp.

Smith, J. L., and Mudd, D. R. 1976. Impact of dredging on the avian fauna in Grays Harbor. IN Maintenance dredging and the environment of Grays Harbor, Washington (ACOE, 1976-1977), Appendix H, 217 pp. U.S. Army Corps of Engineers, Seattle District.

Smith, J. M., Phipps, J. B., Schermer, E. D., and Samuleson, D. F. 1976. Impact of dredging on water quality in Grays Harbor, Washington. IN Proceedings Specialty Conference on Dredging and its Environmental Effects, January 26-28, 1976. Mobile, Alabama. American Society of Civil Engineers, New York. pp. 512-528.

Smith, J. M., Messmer, L. W., Phipps, J. B., Samuelson, D. F., and Schermer, E. D. 1980. Grays Harbor ocean disposal study: Literature review and preliminary benthic sampling. U.S. Army Corps of Engineers, Seattle District. 159 pp.

Stern, E. M., and Stickle, W. B. 1978. Effects of turbidity and suspended material in aquatic environments: Literature review. U.S. Army Eng. Waterways Exp. Stn., Vicksburg, Mississippi. Tech. Rep. D-78-21.

Taylor, J. L., and Saloman, C. H. 1967. Some effects of hydraulic dredging and coastal development in Boga Ciega Bay, Florida. Fish Bull. 67(2):213-241.

Taylor, J. L. (undated). Some effects of oyster shell dredging on benthic invertebrates in Mobile Bay, Alabama. National Marine Fisheries Service, St. Petersburg Beach, Florida. (unpublished)

U.S. Army Corps of Engineers. 1971. National shoreline study. Inventory report, Columbia-North Pacific Region, Washington and Oregon. U.S. Army Corps of Engineers, North Pacific Division. 80 pp. + 50 plates.

U.S. Army Corps of Engineers. 1975. Maintenance dredging existing navigation projects, San Francisco Bay Region, California. Final composite environmental statement. U.S. Army Corps of Engineers, San Francisco District.

U.S. Army Corps of Engineers. 1976. Port of Grays Harbor/Kaiser Steel Corporation. Final environmental impact statement. U.S. Army Corps of Engineers, Seattle District. 334 pp.

U.S. Army Corps of Engineers. 1981. Preliminary results of surface/bottom drifter release study. Unpublished memorandum for record.

U.S. Army Corps of Engineers, Seattle District. Personal communication.

Valenti, R. J., and Peters, S. 1977. Aquatic disposal field investigations, Eatons Neck disposal site, Long Island Sound, Appendix D: Predisposal baseline conditions of demersal fish assemblages. New York Ocean Science Lab., Montauk. Published by U.S. Army Eng. Waterways Exp. Stn., Vicksburg, Mississippi. Tech. Rep. D-77-6.

Washington Public Ports Association. 1980. 1980 port system study for the public ports of Washington State. 27 pp.

Wise, J. P., and Thompson, B. G. 1977. Fishery statistics of the United States, 1974. Statistical Digest No. 68, Data Management and Statistics Division, National Marine Fisheries Service, NOAA, Seattle, Washington. 424 pp.

Wright, T. D. 1978. Aquatic dredged material disposal impacts, U.S. Army Eng. Waterways Exp. Stn., Vicksburg, Mississippi. Tech. Rep. DS-78-1.

Yocum, C. F., and Keller, M. 1961. Correlation of food habits and abundance of waterfowl, Humboldt Bay, California. Calif. Fish and Game 47(1):41-53.

APPENDIX A

The following lists of community composition are taken from Proctor et al. (1980). All species listed are known to occur in the Grays Harbor Estuary. The list is not exhaustive. Only the most common, characteristic, or significant plants (vascular or nonvascular) have been entered due to the large numbers present. Likewise, only a sampling of the major invertebrates were entered for the same reason. Sources of data are given in Proctor et al. (1980). Nearshore oceanic species are listed in Smith et al. (1980).

KEY TO SYMBOLS

Abundance

A - Abundant
C - Common
U - Unknown
0 - Present abundance unknown

Status

R - Rare
E - Endangered
T - Threatened
P - Peripheral
I - Endemic
EG - Game
C - Commercial
c - Potentially commercial
X - Pest

COMMUNITY COMPOSITION ESTUARY   ZONE: SUBTIDAL

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (1) PRODUCER NON-VASCULAR PLANTS			
CHAETOCEROS DECIPIENS DIATOMS	123456789	O	-
COSCINODISCUS RADIATUS DIATOMS	123456789	O	-
EUCAMPIA ZODIACUS DIATOMS	123456789	O	-
MELOSIRA MONILIFORMIS DIATOMS	1234567	O	-

HABITAT: CHANNEL

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (1) PRODUCER NON-VASCULAR PLANTS			
SKELETONEMA COSTATUM DIATOMS	123456789	A	-
THALASSIONEMA NITZSCHIOIDES DIATOMS	123456789	O	-
TROPHIC LEVEL: (2) HERBIVORE INVERTEBRATES			
HARPACTICOID COPEPOD	123456789	A	-
TROPHIC LEVEL: (2) HERBIVORE FISHES			
CATOSTOMUS MACROCHEILUS LARGESCALE SUCKER	1234567	C	-
TROPHIC LEVEL: (2) HERBIVORE BIRDS			
AYTHYA VALISINERIA CANVASBACK	123456789	C	G
FULICA AMERICANA AMERICAN COOT	123456789	C	G
OXYURA JAMAICENSIS RUDDY DUCK	123456789	C	G
TROPHIC LEVEL: (3) CARNIVORE FISHES			
ACIPENSER MEDIROSTRIS GREEN STURGEON	123456789	C	G
ACIPENSER TRANSMONTANUS WHITE STURGEON	123456789	C	G
ALEPISAURUS FEROX LONGNOSE LANCETFISH	123456789	U	-
AMPHISTICHUS RHODOTERUS REDTAIL SURFPERCH	123456789	C	G
ANARRHICHTHYS OCELLATUS WOLF-EEL	123456789	O	-

COMMUNITY COMPOSITION ESTUARY ZONE: SUBTIDAL

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (3) CARNIVORE — FISHES			
ARTEDIUS FENESTRALIS / PADDED SCULPIN	123456789	O	-
BRAMA JAPONICA / POMFRET	123456789	U	-
CITHARICHTHYS STIGMAEUS / SPECKLED SANDDAB	123456789	O	G
COTTUS ASPER / PRICKLY SCULPIN	123456789	A	-
ENOPHRYS BISON / BUFFALO SCULPIN	123456789	O	-
HEXAGRAMMOS DECAGRAMMUS / KELP GREENLING	123456789	O	G
MORONE SAXATILIS / STRIPED BASS	123456789	C	G
ONCORHYNCHUS GORBUSCHA / PINK SALMON	123456789	U	C
ONCORHYNCHUS KETA / CHUM SALMON	123456789	U	C
ONCORHYNCHUS KISUTCH / COHO SALMON	123456789	C	C
ONCORHYNCHUS TSHAWYTSCHA / CHINOOK SALMON /JUVENILE	123456789	O	-
ONCORHYNCHUS TSHAWYTSCHA / CHINOOK SALMON	123456789	C	C
OPHIODON ELONGATUS / LINGCOD	123456789	U	C
PALLASINA BARBATA / TUBENOSE POACHER	123456789	O	-
PAROPHRYS VETULUS / ENGLISH SOLE	123456789	O	G
PEPRILUS SIMILLIMUS / PACIFIC POMPANO	123456789	O	G
PLATICHTHYS STELLATUS / STARRY FLOUNDER	123456789	A	G
PSETTICHTHYS MELANOSTICTUS / SAND SOLE	123456789	O	G
SALMO CLARKI / CUTTHROAT TROUT	123456789	C	G
SALMO GAIRDNERI / RAINBOW TROUT	123456789	U	C
SALVELINUS MALMA / DOLLY VARDEN	123456789	U	G
SCORPAENICHTHYS MARMORATUS / CABEZON	123456789	C	G
SEBASTES CAURINUS / COPPER ROCKFISH	123456789	C	G
SEBASTES MELANOPS / BLACK ROCKFISH	123456789	C	G

HABITAT: CHANNEL

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (3) CARNIVORE — FISHES			
SEBASTES PAUCISPINIS / BOCACCIO	123456789	U	G
SQUALUS ACANTHIAS / SPINY DOGFISH	123456789	A	-
TROPHIC LEVEL: (3) CARNIVORE — BIRDS			
AECHMOPHORUS OCCIDENTALIS / WESTERN GREBE	123456789	C	-
BRACHYRAMPHUS MARMORATUM / MARBLED MURRELET	123456789	U	-
BUCEPHALA ALBEOLA / BUFFLEHEAD	123456789	C	G
BUCEPHALA CLANGULA / COMMON GOLDENEYE	123456789	C	G
CEPPHUS COLUMBA / PIGEON GUILLEMOT	123456789	C	-
CLANGULA HYEMALIS / OLDSQUAW	123456789	U	G
GAVIA ARCTICA / ARCTIC LOON	123456789	U	-
GAVIA IMMER / COMMON LOON	123456789	C	-
GAVIA STELLATA / RED-THROATED LOON	123456789	C	-
HISTRIONICUS HISTRIONICUS / HARLEQUIN DUCK	123456789	U	G
LARUS ARGENTATUS / HERRING GULL	123456789	U	-
LARUS CALIFORNICUS / CALIFORNIA GULL	123456789	A	-
LARUS CANUS / MEW GULL	123456789	A	-
LARUS DELAWARENSIS / RING-BILLED GULL	123456789	C	-
LARUS GLAUCESCENS / GLAUCOUS-WINGED GULL	123456789	A	-
LARUS HEERMANNI / HEERMANNS GULL	123456789	C	-
LARUS OCCIDENTALIS / WESTERN GULL	123456789	A	-
LARUS PHILADELPHIA / BONAPARTE'S GULL	123456789	A	-
LARUS THAYERI / THAYER'S GULL	123456789	U	-
MEGACERYLE ALCYON / BELTED KINGFISHER	123456789	U	-
MELANITTA DEGLANDI / WHITE-WINGED SCOTER	123456789	C	G

COMMUNITY COMPOSITION ESTUARY   ZONE: SUBTIDAL   HABITAT: CHANNEL

SCIENTIFIC NAME COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (3) CARNIVORE BIRDS			
MELANITTA NIGRA BLACK SCOTER	123456789	U	G
MELANITTA PERSPICILLATA SURF SCOTER	123456789	C	G
MERGUS MERGANSER COMMON MERGANSER	123456789	U	G
MERGUS SERRATOR RED-BREASTED MERGANSER	123456789	C	G
PANDION HALIAETUS OSPREY	123456789	U	R
PELECANUS OCCIDENTALIS BROWN PELICAN	23456789	U	E
PHALACROCORAX AURITUS DOUBLE-CRESTED CORMORANT	123456789	C	-
PHALACROCORAX PELAGICUS PELAGIC CORMORANT	123456789	C	-
PHALACROCORAX PENICILLATUS BRANDTS CORMORANT	123456789	C	-
PODICEPS AURITUS HORNED GREBE	123456789	C	-
PODICEPS CASPICUS EARED GREBE	123456789	C	-
PODICEPS GRISEGENA RED-NECKED GREBE	123456789	C	-
PODILYMBUS PODICEPS PIED-BILLED GREBE	123456789	U	-
RISSA TRIDACTYLA BLACK-LEGGED KITTIWAKE	123456789	U	-
STERNA CASPIA CASPIAN TERN	123456789	U	-
STERNA HIRUNDO COMMON TERN	123456789	U	-
URIA AALGE COMMON MURRE	123456789	C	-
TROPHIC LEVEL: (3) CARNIVORE MAMMALS			
PHOCA VITULINA HARBOR SEAL	123456789	A	-
TROPHIC LEVEL: (5) OMNIVORE FISHES			
ANOPLARCHUS PURPURESCENS HIGH COCKSCOMB	123456789	O	-
HYPERPROSOPON ARGENTEUM WALLEYE SURFPERCH	123456789	O	-

SCIENTIFIC NAME COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (5) OMNIVORE FISHES			
LEPIDOGOBIUS LEPIDUS BAY GOBY	123456789	O	-
PHANERODON FURCATUS WHITE SEAPERCH	123456789	C	-
TROPHIC LEVEL: (5) OMNIVORE BIRDS			
AYTHYA AFFINIS LESSER SCAUP	123456789	U	G
AYTHYA MARILA GREATER SCAUP	123456789	C	G
TROPHIC LEVEL: (6) PARASITE INVERTEBRATES			
CLAUSIDIUM VANCOUVERENSE COPEPOD	270	O	-
TROPHIC LEVEL: (6) PARASITE FISHES			
LAMPETRA AYRESI RIVER LAMPREY	123456789	C	-
			-
LAMPETRA RICHARDSONI WESTERN BROOK LAMPREY	12345679	O	-
TROPHIC LEVEL: (7) FILTER FEEDER INVERTEBRATES			
ANISOGAMMARUS PUGETTENSIS AMPHIPOD	123456789	O	-
MODIOLUS -NULL-	270	C	-
TROPHIC LEVEL: (9) INVERTEBRATE EATER INVERTEBRATES			
CANCER MAGISTER DUNGENESS CRAB	123456789	A	C
CRANGON ALBA WHITE SHRIMP	20	C	-

COMMUNITY COMPOSITION ESTUARY ZONE: SUBTIDAL

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (9) INVERTEBRATE EATER INVERTEBRATES			
CRANGON FRANCISCORUM -NULL-	123456789	O	-
CRANGON NIGRICAUDA BLACK-TAILED SHRIMP	123456789	O	-
NEOMYSIS MERCEDIS MYSID SHRIMP	320	O	-
NEPHTYS CAECA NEREID WORM	270	C	-
TROPHIC LEVEL: (9) INVERTEBRATE EATER FISHES			
ALLOSMERUS ELONGATUS WHITEBAIT SMELT	123456789	O	-
AMMODYTES HEXAPTERUS PACIFIC SAND LANCE	123456789	A	C
APODICHTHYS FLAVIDUS PENPOINT GUNNEL	123456789	O	-
ATHERINOPS AFFINIS TOPSMELT	123456789	O	-
AULORHYNCHUS FLAVIDUS TUBESNOUT	123456789	O	-
CLINOCOTTUS GLOBICEPS MOSSHEAD SCULPIN	123456789	O	-
CLUPEA HARENGUS PALLASI PACIFIC HERRING	123456789	C	C
CYMATOGASTER AGGREGATA SHINER PERCH	123456789	A	-
EMBIOTOCA LATERALIS STRIPED SEAPERCH	123456789	O	G
ENGRAULIS MORDAX NORTHERN ANCHOVY	123456789	C	C
GASTEROSTEUS ACULEATUS THREESPINE STICKLEBACK	123456789	C	-
HYPOMESUS PRETIOSUS SURFSMELT	123456789	O	C
LEPTOCOTTUS ARMATUS PACIFIC STAGHORN SCULPIN	123456789	A	-
LUMPENUS SAGITTA SNAKE PRICKLEBACK	123456789	A	-

HABITAT: CHANNEL

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (9) INVERTEBRATE EATER FISHES			
MICROGADUS PROXIMUS PACIFIC TOMCOD	123456789	A	-
OLIGOCOTTUS SNYDERI FLUFFY SCULPIN	123456789	O	-
ONCORHYNCHUS GORBUSCHA PINK SALMON /JUVENILE	123456789	O	-
ONCORHYNCHUS KETA CHUM SALMON /JUVENILE	123456789	O	-
ONCORHYNCHUS KISUTCH COHO SALMON /JUVENILE	123456789	O	-
ONCORHYNCHUS NERKA SOCKEYE SALMON /JUVENILE	123456789	O	-
ONCORHYNCHUS NERKA SOCKEYE SALMON	123456789	U	C
RHACOCHILUS VACCA PILE PERCH	123456789	C	G
RHINICHTHYS OSCULUS SPECKLED DACE	123456789	O	-
RICHARDSONIUS BALTEATUS REDSIDE SHINER	12347	C	-
SPIRINCHUS THALEICHTHYS LONGFIN SMELT	123456789	A	-
SYNGNATHUS GRISEOLINEATUS BAY PIPEFISH	123456789	A	-
THALEICHTHYS PACIFICUS EULACHON	123456789	A	-
TROPHIC LEVEL: (9) INVERTEBRATE EATER BIRDS			
LOBIPES LOBATUS NORTHERN PHALAROPE	123456789	U	-
PHALAROPUS FULICARIUS RED PHALAROPE	123456789	R	-
TROPHIC LEVEL: (0) UNKNOWN INVERTEBRATES			
ACARTIA CLAUSII COPEPOD	123456789	A	-
ACARTIA LONGIREMIS COPEPOD	123456789	A	-

COMMUNITY COMPOSITION ESTUARY   ZONE: SUBTIDAL   HABITAT: CHANNEL

SCIENTIFIC NAME COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (0) UNKNOWN INVERTEBRATES			
STENOCALANUS NANUS COPEPOD	123456789	C	-
DIASTYLIS CUMACEAN	20	C	-
ETEONE LONGA POLYCHAETE WORM	20	C	-
GLYCINDE ARMIGERA POLYCHAETE WORM	270	U	-
NOTOMASTUS TENUIS LUGWORMS	270	U	-
PARACALANUS PARVUS COPEPODS	123456789	C	-
PARAPHOXUS MILLERI AMPHIPODS	2789	O	-
PARAPLEUSTHES PUGETTENSIS AMPHIPODS	123456789	O	-
POLYDORA LIGNI SPIONID WORM	270	U	-
PONTOGENIA INERMIS AMPHIPODS	123456789	O	-
PSEUDOCALANUS COPEPOD	123456789	A	-
PSEUDOPOLYDORA KEMPI SPIONID WORM	270	A	-
STREBLOSPIO BENEDICTI SPIONID WORM	270	A	-
TROPHIC LEVEL: (0) UNKNOWN FISHES			
PHOLIS ORNATA SADDLEBACK GUNNEL	123456789	A	-

COMMUNITY COMPOSITION ESTUARY ZONE: SUBTIDAL

SCIENTIFIC NAME COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (1) PRODUCER NON-VASCULAR PLANTS			
CHAETOMORPHA CANNABINNA GREEN ALGAE	123456789	C	-
TROPHIC LEVEL: (2) HERBIVORE BIRDS			
AYTHYA VALISINERIA CANVASBACK	123456789	C	G
FULICA AMERICANA AMERICAN COOT	123456789	C	G
OLOR COLUMBIANUS WHISTLING SWAN	123456789	U	-
OXYURA JAMAICENSIS RUDDY DUCK	123456789	C	G
TROPHIC LEVEL: (3) CARNIVORE FISHES			
CITHARICHTHYS STIGMAEUS SPECKLED SANDDAB	123456789	O	G
RAJA RHINA LONGNOSE SKATE	123456789	C	-
SQUALUS ACANTHIAS SPINY DOGFISH	123456789	A	-
TROPHIC LEVEL: (3) CARNIVORE BIRDS			
BUCEPHALA ALBEOLA BUFFLEHEAD	123456789	C	G
BUCEPHALA CLANGULA COMMON GOLDENEYE	123456789	C	G
MELANITTA DEGLANDI WHITE-WINGED SCOTER	123456789	C	G
MELANITTA PERSPICILLATA SURF SCOTER	123456789	C	G
MERGUS MERGANSER COMMON MERGANSER	123456789	U	G
MERGUS SERRATOR RED-BREASTED MERGANSER	123456789	C	G
PHALACROCORAX AURITUS DOUBLE-CRESTED CORMORANT	123456789	C	-
PHALACROCORAX PELAGICUS PELAGIC CORMORANT	123456789	U	-
PHALACROCORAX PENICILLATUS BRANDT'S CORMORANT	123456789	U	-
TROPHIC LEVEL: (3) CARNIVORE MAMMALS			
PHOCA VITULINA HARBOR SEAL	123456789	C	-

HABITAT: MUD FLAT

SCIENTIFIC NAME COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (4) DETRITIVORE INVERTEBRATES			
COROPHIUM BREVIS AMPHIPOD	123456789	O	-
COROPHIUM SALMONIS AMPHIPOD	1234567	O	-
COROPHIUM SPINICORNE AMPHIPOD	123456789	A	-
MACOMA BALTHICA CLAM	123456789	A	-
MACOMA NASUTA BENT-NOSED CLAM	123456789	A	-
TROPHIC LEVEL: (5) OMNIVORE BIRDS			
AYTHYA AFFINIS LESSER SCAUP	123456789	U	G
AYTHYA MARILA GREATER SCAUP	123456789	C	G
TROPHIC LEVEL: (6) PARASITE INVERTEBRATES			

COMMUNITY COMPOSITION ESTUARY ZONE: SUBTIDAL

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (7) FILTER FEEDER INVERTEBRATES			
ANISOGAMMARUS PUGETTENSIS / AMPHIPOD	123456789	C	-
CLINOCARDIUM NUTTALLII / BASKET COCKLE OR HEART COCKLE	123456789	A	G
MYA ARENARIA / SOFT-SHELL CLAM	123456789	A	G
TAPES JAPONICA / -NULL-	29	O	-
TELLINA MODESTA / TELLEN	123456789	A	-
TELLINA NUCULOIDES / TELLEN	123456789	A	-
TRESUS CAPAX / GAPER CLAM OR EMPIRE CLAM	123456789	A	G
TRESUS NUTTALLII / SOUTHERN GAPER	123456789	A	G
TROPHIC LEVEL: (8) INVERTEBRATE EATER INVERTEBRATES			
CRANGON ALBA / WHITE SHRIMP	20	C	-
CRANGON FRANCISCORUM / -NULL-	123456789	C	-
CRANGON NIGRICAUDA / BLACK-TAILED SHRIMP	123456789	C	-
GLYCERA AMERICANA / POLYCHAETE WORM	123456789	A	-
HARMOTHOE IMBRICATA / POLYNOID WORMS	270	U	-
HESPERONOE COMPLANATA / POLYNOID WORMS	270	C	-
NEOMYSIS MERCEDIS / MYSID SHRIMP	320	A	-
NEPHTYS CAECA / NEREID WORM	270	U	-
NEREIS BRANDTI / NEREID WORM	270	A	-
TROPHIC LEVEL: (9) INVERTEBRATE EATER FISHES			

HABITAT: MUD FLAT

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (?) UNKNOWN INVERTEBRATES			
CAPITELLA CAPITATA / LUGWORMS	270	A	-
DIASTYLIS / CUMACEAN	20	U	-
ETEONE LONGA / POLYCHAETE WORM	20	C	-
GLYCERA CAPITATA / POLYCHAETE WORM	70	U	-
GLYCINDE ARMIGERA / POLYCHAETE WORM	270	C	-
HAPLOSCOLOPUS ELONGATA / POLYCHAETE WORM	270	C	-
HEMIPODUS BOREALIS / POLYCHAETE WORM	70	O	-
HETEROMASTUS FILIFORMIS / LUGWORMS	270	A	-
LEPTOCHELIA SAVIGNYI / CRUSTACEAN	20	A	-
LEPTOCUMA / CUMACEAN	20	C	-
MANAYUNKIA ESTUARINA / SABELLID WORM	20	C	-
MEDIOMASTUS CALIFORNIENSIS / LUGWORMS	2739	C	-
PARCOLUS CALIFORNIENSIS / CRUSTACEAN	20	A	-
PSEUDOPOLYDORA KEMPI / SPIONID WORM	270	C	-
STREBLOSPIO BENEDICTI / SPIONID WORM	270	A	-
SYLLIS ELONGATA / POLYCHAETE WORM	270	U	-
NOTOMASTUS TENUIS / LUGWORMS	270	C	-
SCOLOPLOS ARMIGER / POLYCHAETE WORM	20	O	-

COMMUNITY COMPOSITION ESTUARY   ZONE: SUBTIDAL   HABITAT: SAND FLAT

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (1) PRODUCER — NON-VASCULAR PLANTS			
BRYOPSIS HYPNOIDES / GREEN ALGAE	123456789	U	-
CERAMIUM CALIFORNICUM / POTTERY SEAWEED	123456789	C	-
ENTEROMORPHA TUBULOSA / GREEN ALGAE	123456789	U	-
GRACILARIA SJOESTEDII / RED ALGAE	123456789	C	-
GRACILARIOPHILA ORYZOIDES / RED ALGAE	123456789	O	-
ULVA FENESTRATA / GREEN ALGAE	123456789	U	-
ULVA LACTUCA / SEA LETTUCE	123456789	A	-
ULVA LOBATA / ULVA	123456789	U	-
ULVA TAENIATA / GREEN ALGAE	123456789	U	-
TROPHIC LEVEL: (1) PRODUCER — VASCULAR PLANTS			
SIDALCEA HENDERSONII * / HENDERSONS CHECKER-MALLOW	123456	U	-
TROPHIC LEVEL: (2) HERBIVORE — INVERTEBRATES			
TROPHIC LEVEL: (2) HERBIVORE — FISHES			
CATOSTOMUS MACROCHEILUS / LARGESCALE SUCKER	1234567	O	-
TROPHIC LEVEL: (2) HERBIVORE — BIRDS			
ANSER ALBIFRONS / WHITE-FRONTED GOOSE	123456789	U	G
AYTHYA VALISINERIA / CANVASBACK	123456789	C	G
CHEN CAERULESCENS / SNOW GOOSE	123456789	U	G

* INTERTIDAL

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (3) CARNIVORE — INVERTEBRATES			
PISASTER BREVISPINUS / STAR FISH OR SEA STARS	123456789	O	-
POLINICES LEWISII / MOON SNAIL	123456789	U	-
TROPHIC LEVEL: (3) CARNIVORE — FISHES			
ACIPENSER MEDIROSTRIS / GREEN STURGEON	123456789	C	G
ACIPENSER TRANSMONTANUS / WHITE STURGEON	123456789	C	G
ARTEDIUS FENESTRALIS / PADDED SCULPIN	123456789	O	-
CITHARICHTHYS STIGMAEUS / SPECKLED SANDDAB	123456789	A	G
ENOPHRYS BISON / BUFFALO SCULPIN	123456789	C	-
ONCORHYNCHUS TSHAWYTSCHA / CHINOOK SALMON /JUVENILE	123456789	A	-
PAROPHRYS VETULUS / ENGLISH SOLE	123456789	A	G
PLATICHTHYS STELLATUS / STARRY FLOUNDER	123456789	O	G
PSETTICHTHYS MELANOSTICTUS / SAND SOLE	123456789	C	G
RAJA RHINA / LONGNOSE SKATE	123456789	U	-
SALMO CLARKI / CUTTHROAT TROUT	123456789	C	G
SALVELINUS MALMA / DOLLY VARDEN	123456789	U	G
SQUALUS ACANTHIAS / SPINY DOGFISH	123456789	A	-
TROPHIC LEVEL: (3) CARNIVORE — BIRDS			
AECHMOPHORUS OCCIDENTALIS / WESTERN GREBE	123456789	C	-
BUCEPHALA ALBEOLA / BUFFLEHEAD	123456789	C	G
BUCEPHALA CLANGULA / COMMON GOLDENEYE	123456789	C	G
MELANITTA DEGLANDI / WHITE-WINGED SCOTER	123456789	C	G
MELANITTA NIGRA / BLACK SCOTER	123456789	U	G
MELANITTA PERSPICILLATA / SURF SCOTER	123456789	C	G

COMMUNITY COMPOSITION ESTUARY ZONE: SUBTIDAL HABITAT: SAND FLAT

TROPHIC LEVEL: (3) CARNIVORE

BIRDS

SCIENTIFIC NAME	COMMON NAME	RANGE	ABUNDANCE	STATUS
MERGUS MERGANSER	COMMON MERGANSER	123456789	U	G
MERGUS SERRATOR	RED-BREASTED MERGANSER	123456789	C	G
PHALACROCORAX AURITUS	DOUBLE-CRESTED CORMORANT	123456789	C	-
PHALACROCORAX PELAGICUS	PELAGIC CORMORANT	123456789	U	-
PHALACROCORAX PENICILLATUS	BRANDT'S CORMORANT	123456789	U	-
PODICEPS AURITUS	HORNED GREBE	123456789	C	-
PODICEPS GRISEGENA	RED-NECKED GREBE	123456789	C	-
STERNA CASPIA	CASPIAN TERN	123456789	X	-

MAMMALS

SCIENTIFIC NAME	COMMON NAME	RANGE	ABUNDANCE	STATUS
PHOCA VITULINA	HARBOR SEAL	123456789	C	-

TROPHIC LEVEL: (4) DETRITIVORE

INVERTEBRATES

SCIENTIFIC NAME	COMMON NAME	RANGE	ABUNDANCE	STATUS
ANISOGAMMARUS CONFERVICOLUS	PILL BUGS	20	C	-
CALLIANASSA CALIFORNIENSIS	GHOST SHRIMP	123456789	A	-
CALLIANASSA GIGAS	GHOST SHRIMP	20	U	-
COROPHIUM ACHERUSICUM	AMPHIPOD	123456789	O	-
COROPHIUM BREVIS	AMPHIPOD	123456789	O	-
COROPHIUM OAKLANDENSE	AMPHIPOD	20	O	-
COROPHIUM SALMONIS	AMPHIPOD	1234567	O	-
COROPHIUM SPINICORNE	AMPHIPOD	123456789	C	-
COROPHIUM STIMPSONI	AMPHIPOD	20	A	-
EUZONUS MUCRONATA	POLYCHAETE WORM	123456789	C	-

TROPHIC LEVEL: (4) DETRITIVORE

INVERTEBRATES

SCIENTIFIC NAME	COMMON NAME	RANGE	ABUNDANCE	STATUS
MACOMA BALTHICA	CLAM	123456789	A	-
MACOMA NASUTA	BENT-NOSED CLAM	123456789	A	-
ORCHESTOIDEA CALIFORNIANA	BEACH HOPPER	123456789	A	-
PYGOSPIO ELEGANS	SPIONID WORM	20	A	-

TROPHIC LEVEL: (5) OMNIVORE

FISHES

SCIENTIFIC NAME	COMMON NAME	RANGE	ABUNDANCE	STATUS
CLEVELANDIA IOS	ARROW GOBY	123456789	C	-
HYPERPROSOPON ARGENTEUM	WALLEYE SURFPERCH	123456789	O	-

TROPHIC LEVEL: (5) OMNIVORE

BIRDS

SCIENTIFIC NAME	COMMON NAME	RANGE	ABUNDANCE	STATUS
AYTHYA AFFINIS	LESSER SCAUP	123456789	U	G
AYTHYA MARILA	GREATER SCAUP	123456789	C	G

TROPHIC LEVEL: (6) PARASITE

INVERTEBRATES

SCIENTIFIC NAME	COMMON NAME	RANGE	ABUNDANCE	STATUS
MALACOBDELLA GROSSA	RIBBON WORMS	123456789	U	-

TROPHIC LEVEL: (7) FILTER FEEDER

INVERTEBRATES

SCIENTIFIC NAME	COMMON NAME	RANGE	ABUNDANCE	STATUS
CRASSOSTREA GIGAS	PACIFIC OR JAPANESE OYSTER	123456789	A	C
CRYPTOMYA CALIFORNICA	SOFT-SHELL CLAM	123456789	A	-
EMERITA ANALOGA	MOLE CRAB	123456789	U	-
LYONSIA CALIFORNICA	CALIFORNIA PAPERSHELL	123456789	U	-
MYA ARENARIA	SOFT-SHELL CLAM	123456789	A	G

COMMUNITY COMPOSITION ESTUARY   ZONE: SUBTIDAL   HABITAT: SAND FLAT

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (0) UNKNOWN — INVERTEBRATES			
AGLAJA DIOMEDEA / SLUG	123456789	A	-
CANCER OREGONENSIS / TRUE CRABS	270	C	-
DIASTYLIS / CUMACEAN	20	U	-
EOHAUSTORIUS ESTUARIIS / AMPHIPOD	20	A	-
ETEONE LONGA / POLYCHAETE WORM	20	C	-
HETEROMASTUS FILIFORMIS / LUGWORMS	270	C	-
LEPTOCUMA / CUMACEAN	20	C	-
NASSARIUS PROPINGUS / SNAIL	20	O	-
POLINICES DRACONIS / SNAIL	20	O	-
PONTOGENIA INERMIS / AMPHIPODS	123456789	O	-
PSEUDOPOLYDORA KEMPI / SPIONID WORM	270	C	-
SCOLOPOIOS ARMIGER / POLYCHAETE WORM	20	O	-

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (0) UNKNOWN — FISHES			
PHOLIS ORNATA / SADDLEBACK GUNNEL	123456789	C	-

COMMUNITY COMPOSITION ESTUARY   ZONE: SUBTIDAL   HABITAT: SAND FLAT

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (7) FILTER FEEDER INVERTEBRATES			
PROTOTHACA STAMINEA / COMMON LITTLENECK OR ROCK COCK	123456789	A	G
SAXIDOMUS GIGANTEUS / WASHINGTON CLAM	123456789	A	G
SILIQUA PATULA / RAZOR CLAM	123456789	A	G
TAPES JAPONICA / -NULL-	20	O	-
TROPHIC LEVEL: (8) SCAVENGER INVERTEBRATES			
OLIVELLA BIPLICATA / PURPLE OLIVE SNAIL	123456789	C	-
TROPHIC LEVEL: (3) INVERTEBRATE EATER INVERTEBRATES			
CANCER MAGISTER / DUNGENESS CRAB	123456789	A	C
CANCER PRODUCTUS / TRUE CRABS	270	A	G
CEREBRATULUS CALIFORNIENSIS / RIBBON WORMS	270	U	-
NEPHTYS CAECA / NEREID WORM	270	C	-
NEPHTYS FERRUGINEA / NEREID WORM	20	C	-

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (3) INVERTEBRATE EATER FISHES			
ALLOSMERUS ELONGATUS / WHITEBAIT SMELT	123456789	O	-
AMMODYTES HEXAPTERUS / PACIFIC SAND LANCE	123456789	A	C
CLUPEA HARENGUS PALLASI / PACIFIC HERRING	123456789	A	C
CYMATOGASTER AGGREGATA / SHINER PERCH	123456789	A	-
ENGRAULIS MORDAX / NORTHERN ANCHOVY	123456789	A	C
GASTEROSTEUS ACULEATUS / THREESPINE STICKLEBACK	123456789	O	-
HYPOMESUS PRETIOSUS / SURFSMELT	123456789	A	C
LEPTOCOTTUS ARMATUS / PACIFIC STAGHORN SCULPIN	123456789	A	-
OLIGOCOTTUS SNYDERI / FLUFFY SCULPIN	123456789	O	-
ONCORHYNCHUS GORBUSCHA / PINK SALMON /JUVENILE	123456789	O	-
ONCORHYNCHUS KETA / CHUM SALMON /JUVENILE	123456789	U	-
ONCORHYNCHUS NERKA / SOCKEYE SALMON /JUVENILE	123456789	U	-
TROPHIC LEVEL: (3) INVERTEBRATE EATER BIRDS			
ACTITIS MACULARIA * / SPOTTED SANDPIPER	123456789	U	-
ACTITIS MACULARIA * / SPOTTED SANDPIPER	123456789	U	-

* INTERTIDAL

COMMUNITY COMPOSITION ESTUARY   ZONE: SUBTIDAL   HABITAT: EELGRASS

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (1) PRODUCER — NON-VASCULAR PLANTS			
BLIDINGIA MINIMA / GREEN ALGAE	123456789	C	-
ENTEROMORPHA INTESTINALIS / LINK CONFETTI	123456789	A	-
ENTEROMORPHA TUBULOSA / GREEN ALGAE	123456789	U	-
SMITHORA NAIADUM / RED FRINGE	123456789	A	-
ULVA FENESTRATA / GREEN ALGAE	123456789	U	-
ULVA LACTUCA / SEA LETTUCE	123456789	A	-
ULVA LOBATA / ULVA	123456789	U	-
ULVA TAENIATA / GREEN ALGAE	123456789	U	-
TROPHIC LEVEL: (1) PRODUCER — VASCULAR PLANTS			
ZOSTERA MARINA / EELGRASS	123456789	A	-
ZOSTERA NOLTII / EELGRASS	20	C	-
TROPHIC LEVEL: (2) HERBIVORE — BIRDS			
ANAS ACUTA / PINTAIL	123456789	C	G
ANAS AMERICANA / AMERICAN WIDGEON	123456789	A	G
ANAS CLYPEATA / NORTHERN SHOVELER	123456789	U	G
ANAS PENELOPE / EUROPEAN WIDGEON	123456789	U	G
ANSER ALBIFRONS / WHITE-FRONTED GOOSE	123456789	U	G
AYTHYA VALISINERIA / CANVASBACK	123456789	C	G
BRANTA BERNICLA / BRANT	123456789	A	G
BRANTA CANADENSIS / CANADA GOOSE	123456789	C	G
CHEN CAERULESCENS / SNOW GOOSE	123456789	U	G
FULICA AMERICANA / AMERICAN COOT	123456789	C	G

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (3) CARNIVORE — FISHES			
ARTEDIUS FENESTRALIS / PADDED SCULPIN	123456789	O	-
CITHARICHTHYS STIGMAEUS / SPECKLED SANDDAB	123456789	O	G
ONCORHYNCHUS TSHAWYTSCHA / CHINOOK SALMON /JUVENILE	123456789	C	-
PAROPHRYS VETULUS / ENGLISH SOLE	123456789	A	G
PSETTICHTHYS MELANOSTICTUS / SAND SOLE	123456789	O	G
SALMO CLARKI / CUTTHROAT TROUT	123456789	C	G
SALVELINUS MALMA / DOLLY VARDEN	123456789	U	G
TROPHIC LEVEL: (3) CARNIVORE — BIRDS			
BUTORIDES STRIATUS / GREEN HERON	123456789	U	-
TROPHIC LEVEL: (4) DETRITIVORE — INVERTEBRATES			
ANOBOTHRUS GRACILIS / BRISTLE WORMS	270	U	-
COROPHIUM BREVIS / AMPHIPOD	123456789	O	-
COROPHIUM SALMONIS / AMPHIPOD	1234567	O	-
COROPHIUM STIMPSONI / AMPHIPOD	20	A	-
IDOTEA FEWKESI / PILL BUGS	270	C	-
IDOTEA RUFESCENS / ISOPOD	20	C	-
IDOTEA WOSNESENSKII / PILL BUGS	270	A	-
MACOMA BALTHICA / CLAM	123456789	A	-
MACOMA INCONSPICUA / CLAM	123456789	C	-
MACOMA NASUTA / BENT-NOSED CLAM	123456789	A	-
ORCHESTIA TRASKIANA / BEACH HOPPER OR SAND FLEA	123456789	A	-
TRICHOCORIXA VERTICALIS CALIFO / WATER BOATMAN	123456789	U	I

COMMUNITY COMPOSITION ESTUARY   ZONE: SUBTIDAL   HABITAT: EELGRASS

SCIENTIFIC NAME COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (5) OMNIVORE FISHES			
CLEVELANDIA IOS ARROW GOBY	123456789	C	-
TROPHIC LEVEL: (5) OMNIVORE BIRDS			
AYTHYA AFFINIS LESSER SCAUP	123456789	U	G
AYTHYA MARILA GREATER SCAUP	123456789	C	G
TROPHIC LEVEL: (6) PARASITE INVERTEBRATES			
CLAUSIDIUM VANCOUVERENSE COPEPOD	270	C	-
TROPHIC LEVEL: (7) FILTER FEEDER INVERTEBRATES			
AEDES DORSALIS MOSQUITO	123456789	C	-
ANISOGAMMARUS CONFERVICOLUS AMPHIPOD	123456789	A	-
CLINOCARDIUM NUTTALLII BASKET COCKLE OR HEART COCKLE	123456789	A	G
CRYPTOMYA CALIFORNICA SOFT-SHELL CLAM	123456789	A	-
EPHYDRIDAE NOTIPHILA SHOREFLY	123456789	C	-
TELLINA MODESTA TELLEN	123456789	A	-
TELLINA NUCULOIDES TELLEN	123456789	A	-
TRESUS CAPAX GAPER CLAM OR EMPIRE CLAM	123456789	A	G
TRESUS NUTTALLII SOUTHERN GAPER	123456789	A	G

SCIENTIFIC NAME COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (9) INVERTEBRATE EATER INVERTEBRATES			
BEMBIDION INDISTINCTUM GROUND BEETLE	123456789	C	I
CEREBRATULUS CALIFORNIENSIS RIBBON WORMS	270	U	-
CRANGON ALBA WHITE SHRIMP	20	C	-
CRANGON FRANCISCORUM -NULL-	123456789	C	-
CRANGON NIGRICAUDA BLACK-TAILED SHRIMP	123456789	C	-
HERMISSENDA CRASSICORNIS NUDIBRANCH	123456789	C	-
NEOMYSIS MERCEDIS MYSID SHRIMP	320	A	-
NEREIS BRANDTI NEREID WORM	270	C	-
SALDULA PALUSTRIS SHOREBUG	123456789	C	I
TROPHIC LEVEL: (9) INVERTEBRATE EATER FISHES			
AMMODYTES HEXAPTERUS PACIFIC SAND LANCE	123456789	C	C
ATHERINOPS AFFINIS TOPSMELT	123456789	O	-
CLUPEA HARENGUS PALLASI PACIFIC HERRING	123456789	U	C
CYMATOGASTER AGGREGATA SHINER PERCH	123456789	A	-
ENGRAULIS MORDAX NORTHERN ANCHOVY	123456789	A	C
GASTEROSTEUS ACULEATUS THREESPINE STICKLEBACK	123456789	A	-
HYPOMESUS PRETIOSUS SURFSMELT	123456789	A	C
LEPTOCOTTUS ARMATUS PACIFIC STAGHORN SCULPIN	123456789	A	-
ONCORHYNCHUS GORBUSCHA PINK SALMON /JUVENILE	123456789	O	-
ONCORHYNCHUS KETA CHUM SALMON /JUVENILE	123456789	U	-
ONCORHYNCHUS NERKA SOCKEYE SALMON /JUVENILE	123456789	U	-
SYNGNATHUS GRISEOLINEATUS BAY PIPEFISH	123456789	A	-

COMMUNITY COMPOSITION ESTUARY ZONE: SUBTIDAL HABITAT: EELGRASS

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (3) INVERTEBRATE EATER BIRDS			
CHARADRIUS SEMIPALMATUS * SEMIPALMATED PLOVER	123456789	C	-
TROPHIC LEVEL: (0) INVERTEBRATES			
CAPITELLA LUGWORMS	20	A	-
CAPITELLA CAPITATA LUGWORMS	270	C	-
CAPRELLA AMPHIPOD	20	A	-
EOHAUSTORIUS AMPHIPOD	20	A	-
GLYCINDE ARMIGERA POLYCHAETE WORM	270	C	-
HAPLOSCOLOPUS ELONGATA POLYCHAETE WORM	270	U	-
LACUNA CHINK SHELL	123456789	U	-
LEPTOCHELIA SAVIGNYI CRUSTACEAN	20	A	-
PANCOLUS CALIFORNIENSIS CRUSTACEAN	20	A	-
PHOTIS BREVIPES AMPHIPOD	20	A	-

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (0) INVERTEBRATES			
CIRRATULUS CIRRATUS LUGWORMS	270	C	-
SCOLOPOIOS ARMIGER POLYCHAETE WORM	20	U	-
TROPHIC LEVEL: (0) UNKNOWN FISHES			
PHOLIS ORNATA SADDLEBACK GUNNEL	123456789	C	-

* INTERTIDAL

COMMUNITY COMPOSITION ESTUARY   ZONE: INTERTIDAL   HABITAT: MUD FLAT

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (1) PRODUCER — NON-VASCULAR PLANTS			
BLIDINGIA MINIMA GREEN ALGAE	123456789	C	-
CHAETOMORPHA CANNABINNA GREEN ALGAE	123456789	C	-
CLADOPHORA GREEN ALGAE	123456789	C	-
DESMARESTIA MUNDA WIDE BRANCH COLOR CHANGER	123456789	C	-
ENTEROMORPHA CLATHRATA GREEN ALGAE	123456789	C	-
ENTEROMORPHA INTESTINALIS LINK CONFETTI	123456789	A	-
ENTEROMORPHA LINZA GREEN STRING LETTUCE	123456789	C	-
ENTEROMORPHA SALINA GREEN ALGAE	123456789	A	-
ENTEROMORPHA TUBULOSA GREEN ALGAE	123456789	U	-
FUCUS BROWN ALGAE	123456789	C	-
MICROCOLEUS BLUE GREEN ALGAE	123456789	O	-
OSCILLATORIA BLUE GREEN ALGAE	123456789	A	-
RHIZOCLONIUM LUBRICUM GREEN ALGAE	123456789	A	-
SPIRULINA BLUE GREEN ALGAE	123456789	O	-
ULVA EXPANSA GREEN ALGAE	123456789	U	-
ULVA FENESTRATA GREEN ALGAE	123456789	U	-
ULVA LACTUCA SEA LETTUCE	123456789	A	-
ULVA LOBATA ULVA	123456789	U	-
ULVA TAENIATA GREEN ALGAE	123456789	U	-
TROPHIC LEVEL: (1) PRODUCER — VASCULAR PLANTS			
SCIRPUS MARITIMUS SEACOAST BULRUSH	1234567	C	-
TRIGLOCHIN MARITIMUM SEASIDE ARROWGRASS	123456789	A	-

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (2) HERBIVORE — BIRDS			
ANAS ACUTA PINTAIL	123456789	C	G
ANAS AMERICANA AMERICAN WIDGEON	123456789	A	G
ANAS CLYPEATA NORTHERN SHOVELER	123456789	U	G
ANAS CRECCA GREEN-WINGED TEAL	123456789	C	G
ANAS PENELOPE EUROPEAN WIDGEON	123456789	U	G
ANSER ALBIFRONS WHITE-FRONTED GOOSE	123456789	U	G
CHEN CAERULESCENS SNOW GOOSE	123456789	U	G
COLUMBA FASCIATA BAND-TAILED PIGEON	123456789	A	G
FULICA AMERICANA AMERICAN COOT	123456789	C	G
OLOR COLUMBIANUS WHISTLING SWAN	123456789	U	-
TROPHIC LEVEL: (3) CARNIVORE — INVERTEBRATES			
POLINICES LEWISII MOON SNAIL	123456789	U	-
TROPHIC LEVEL: (3) CARNIVORE — FISHES			
CITHARICHTHYS STIGMAEUS SPECKLED SANDDAB	123456789	O	G
TROPHIC LEVEL: (3) CARNIVORE — BIRDS			
ARDEA HERODIAS GREAT BLUE HERON	123456789	C	-
BUTORIDES STRIATUS GREEN HERON	123456789	U	-
LARUS ARGENTATUS HERRING GULL	123456789	U	-
LARUS CALIFORNICUS CALIFORNIA GULL	123456789	A	-
LARUS CANUS MEW GULL	123456789	A	-
LARUS DELAWARENSIS RING-BILLED GULL	123456789	C	-

KEY TO SYMBOLS 1.1.1 A-2

COMMUNITY COMPOSITION ESTUARY ZONE: INTERTIDAL

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (3) CARNIVORE — BIRDS			
LARUS GLAUCESCENS / GLAUCOUS-WINGED GULL	123456789	A	-
LARUS OCCIDENTALIS / WESTERN GULL	123456789	A	-
LARUS PHILADELPHIA / BONAPARTE'S GULL	123456789	A	-
LARUS THAYERI / THAYER'S GULL	123456789	U	-
TRINGA FLAVIPES / LESSER YELLOWLEGS	123456789	C	-
TROPHIC LEVEL: (3) CARNIVORE — MAMMALS			
PHOCA VITULINA / HARBOR SEAL	123456789	C	-
TROPHIC LEVEL: (4) DETRITIVORE — INVERTEBRATES			
ANISOGAMMARUS CONFERVICOLUS / PILL BUGS	20	C	-
CALLIANASSA CALIFORNIENSIS / GHOST SHRIMP	123456789	A	-
CALLIANASSA GIGAS / GHOST SHRIMP	20	U	-
COROPHIUM BREVIS / AMPHIPOD	123456789	O	-
COROPHIUM SALMONIS / AMPHIPOD	1234567	O	-
COROPHIUM SPINICORNE / AMPHIPOD	123456789	A	-
COROPHIUM STIMPSONI / AMPHIPOD	20	A	-
MACOMA BALTHICA / CLAM	123456789	A	-
MACOMA INCONSPICUA / CLAM	123456789	A	-
MACOMA INQUINATA / CLAM	123456789	C	-
MACOMA NASUTA / BENT-NOSED CLAM	123456789	A	-
PELOSCOLEX GABRIELLE / TUBIFICIDS	20	C	-
TARPHIOTA GENICULATA / ROVE BEETLE	123456789	Q	I

HABITAT: MUD FLAT

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (5) OMNIVORE — INVERTEBRATES			
NASSARIUS OBSOLETUS / BASKET SHELL	123456789	U	-
TROPHIC LEVEL: (5) OMNIVORE — BIRDS			
AYTHYA AFFINIS / LESSER SCAUP	123456789	U	G
AYTHYA MARILA / GREATER SCAUP	123456789	C	G
CORVUS BRACHYRHYNCHOS / COMMON CROW	123456789	U	-
CORVUS CORAX / COMMON RAVEN	123456789	U	-
TROPHIC LEVEL: (5) OMNIVORE — MAMMALS			
PROCYON LOTOR / RACCOON	123456789	C	C
TROPHIC LEVEL: (6) PARASITE — INVERTEBRATES			
ALEOCHARA SULCICOLLIS / ROVE BEETLE	123456789	Q	-
CLAUSIDIUM VANCOUVERENSE / COPEPOD	270	C	-
MALACOBDELLA GROSSA / RIBBON WORMS	123456789	U	-
TROPHIC LEVEL: (7) FILTER FEEDER — INVERTEBRATES			
ANISOGAMMARUS CONFERVICOLUS / AMPHIPOD	123456789	A	-
ANISOGAMMARUS PUGETTENSIS / AMPHIPOD	123456789	C	-
CLINOCARDIUM NUTTALLII / BASKET COCKLE OR HEART COCKLE	123456789	A	G

COMMUNITY COMPOSITION ESTUARY   ZONE: INTERTIDAL

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (7) FILTER FEEDER INVERTEBRATES			
CRASSOSTREA GIGAS PACIFIC OR JAPANESE OYSTER	123456789	A	C
LYONSIA CALIFORNICA CALIFORNIA PAPERSHELL	123456789	U	-
MYA ARENARIA SOFT-SHELL CLAM	123456789	A	G
PROTOTHACA TENERRIMA BIVALVE	123456789	C	-
TAPES JAPONICA -NULL-	20	Q	-
TELLINA MODESTA TELLEN	123456789	A	-
TELLINA NUCULOIDES TELLEN	123456789	A	-
TRESUS CAPAX GAPER CLAM OR EMPIRE CLAM	123456789	A	G
TRESUS NUTTALLII SOUTHERN GAPER	123456789	A	G
UPOGEBIA PUGETTENSIS BLUE MUD SHRIMP	123456789	A	-
TROPHIC LEVEL: (8) SCAVENGER INVERTEBRATES			
TROPHIC LEVEL: (9) INVERTEBRATE EATER INVERTEBRATES			
ALLORCHESTES ANGUSTUS AMPHIPOD	27890	U	-
BLEDIUS MONSTRATUS ROVE BEETLE	123456789	Q	-
CEPHALOBATULUS CALIFORNIENSIS RIBBON WORMS	270	U	-
CRANGON ALBA WHITE SHRIMP	20	C	-
CRANGON FRANCISCORUM -NULL-	123456789	C	-
CRANGON NIGRICAUDA BLACK-TAILED SHRIMP	123456789	C	-
GLYCERA AMERICANA POLYCHAETE WORM	123456789	A	-
HARMOTHOE IMBRICATA POLYNOID WORMS	270	U	-
HESPERONOE COMPLANATA POLYNOID WORMS	270	C	-

HABITAT: MUD FLAT

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (9) INVERTEBRATE EATER INVERTEBRATES			
NEOMYSIS MERCEDIS MYSID SHRIMP	320	A	-
NEPHTYS CAECA NEREID WORM	270	U	-
NEREIS BRANDTI NEREID WORM	270	A	-
SALDULA PALUSTRIS SHORE BUG	123456789	Q	T
THINOBIUS FRIZZELLI ROVE BEETLE	12	Q	T
TROPHIC LEVEL: (9) INVERTEBRATE EATER BIRDS			
ARENARIA INTERPRES RUDDY TURNSTONE	123456789	U	-
ARENARIA MELANOCEPHALA BLACK TURNSTONE	123456789	U	-
ACTITIS MACULARIA SPOTTED SANDPIPER	123456789	U	-
CALIDRIS ALBA SANDERLING	123456789	U	-
CALIDRIS ALPINA DUNLIN	123456789	A	-
CALIDRIS BAIRDII BAIRD'S SANDPIPER	123456789	R	-
CALIDRIS CANUTUS REDKNOT	123456789	U	-
CALIDRIS MAURI WESTERN SANDPIPER	123456789	A	-
CALIDRIS MINUTILLA LEAST SANDPIPER	123456789	C	-
CHARADRIUS VOCIFERUS KILLDEER	123456789	C	-
LIMNODROMUS GRISEUS SHORT-BILLED DOWITCHER	123456789	C	-
LIMNODROMUS SCOLOPACEUS LONG-BILLED DOWITCHER	123456789	C	-

COMMUNITY COMPOSITION ESTUARY   ZONE: INTERTIDAL   HABITAT: MUD FLAT

SCIENTIFIC NAME COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (9) INVERTEBRATE EATER BIRDS			
LIMOSA FEDOA MARBLED GODWIT	123456789	U	-
LOBIPES LOBATUS NORTHERN PHALAROPE	123456789	U	-
NUMENIUS AMERICANUS LONG-BILLED CURLEW	123456789	U	-
NUMENIUS PHAEOPUS WHIMBREL	123456789	U	-
PLUVIALIS DOMINICA AMERICAN GOLDEN PLOVER	123456789	U	-
PLUVIALIS SQUATAROLA BLACK-BELLIED PLOVER	123456789	C	-
TRINGA MELANOLEUCA GREATER YELLOWLEGS	123456789	C	-
TROPHIC LEVEL: (0) UNKNOWN INVERTEBRATES			
AGLAJA DIOMEDEA SLUG	123456789	A	-
AMPHICTEIS MUCRONATA BRISTLE WORMS	20	U	-
CAPITELLA CAPITATA LUGWORMS	270	A	-
ETEONE LONGA POLYCHAETE WORM	20	C	-
GLYCINDE ARMIGERA POLYCHAETE WORM	270	C	-
HAPLOSCOLOPUS ELONGATA POLYCHAETE WORM	270	C	-
HEMIGRAPSUS OREGONENSIS HAIRY SHORE CRAB	270	A	-
HETEROMASTUS FILIFORMIS LUGWORMS	270	A	-
LEPTOCHELIA SAVIGNYI CRUSTACEAN	20	A	-
LEPTOCUMA CUMACEAN	20	C	-
MANAYUNKIA ESTUARINA SABELLID WORM	20	C	-
MEDIOMASTUS CALIFORNIENSIS LUGWORMS	2789	C	-

SCIENTIFIC NAME COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (0) UNKNOWN INVERTEBRATES			
NASSARIUS PROPINGUS SNAIL	20	O	-
NOTOMASTUS TENUIS LUGWORMS	270	C	-
PANCOLUS CALIFORNIENSIS CRUSTACEAN	20	A	-
POLINICES DRACONIS SNAIL	20	O	-
PSEUDOPOLYDORA KEMPI SPIONID WORM 1	270	C	-
SCOLOPOIOS ARMIGER POLYCHAETE WORM	20	O	-
STREBLOSPIO BENEDICTI SPIONID WORM	270	A	-
SYLLIS ELONGATA POLYCHAETE WORM	270	U	-

COMMUNITY COMPOSITION ESTUARY   ZONE: INTERTIDAL   HABITAT: EMERGENT VEGETATION

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (1) PRODUCER — NON-VASCULAR PLANTS			
ANABAENA / BLUE GREEN ALGAE	123456789	O	-
FUCUS / BROWN ALGAE	123456789	C	-
MICROCOLEUS / BLUE GREEN ALGAE	123456789	O	-
OSCILLATORIA / BLUE GREEN ALGAE	123456789	A	-
SPIRULINA / BLUE GREEN ALGAE	123456789	O	-
TROPHIC LEVEL: (1) PRODUCER — VASCULAR PLANTS			
AGROSTIS ALBA / CREEPING BENTGRASS	123456789	A	-
ATRIPLEX PATULA / SALT BUSH	123456789	C	-
BOISDUVALIA DENSIFLORA / SPIKE PRIMROSE	123456789	O	-
CAREX LYNGBYEI / LYNGBYE'S SEDGE	123456789	A	-
CAREX OBNUPTA / SLOUGH SEDGE	123456789	U	-
COTULA CORONOPIFOLIA / BRASS BUTTONS	123456789	C	-
DESCHAMPSIA CAESPITOSA / TUFTED HAIRGRASS	123456789	A	-
DISTICHLIS SPICATA / SEASHORE SALTGRASS	123456789	A	-
ELEOCHARIS PALUSTRIS / COMMON SPIKE-RUSH	123456789	C	-
ELEOCHARIS PARVULA / SMALL SPIKE-RUSH	123456789	C	-
ELYMUS TRITICOIDES / CREEPING RYEGRASS	123456789	O	-
GLAUX MARITIMA / SEA MILKWORT	123456789	A	-
GRINDELIA INTEGRIFOLIA / GUM PLANT	1234567	C	-

SCIENTIFIC NAME / COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (1) PRODUCER — VASCULAR PLANTS			
HOLCUS LANATUS / COMMON VELVET GRASS	123456789	U	-
HORDEUM BRACHYANTHERUM / MEADOW BARLEY	123456789	C	-
HORDEUM JUBATUM / FOXTAIL OR SQUIRREL-TAIL BARLE	123456789	U	-
JAUMEA CARNOSA / JAUMEA	123456789	A	-
JUNCUS BALTICUS / BALTIC RUSH	123456789	C	-
JUNCUS GERARDII / MUD RUSH	123456789	U	*
JUNCUS LESUEURII / SALT RUSH	123456789	C	-
JUNCUS TENUIS / RUSH	123456789	U	-
MYOSURUS MINIMUS / LEAST MOUSE-TAIL	29	O	-
ORTHOCARPUS CASTILLEJOIDES / PAINTBRUSH ORTHOCARPUS	123456789	U	-
PLANTAGO MARITIMA / SEASIDE PLANTAIN	123456789	A	-
PLECTRITIS CONGESTA / ROSY PLECTRITIS	123456789	U	-
POTENTILLA PACIFICA / PACIFIC SILVERWEED	123456789	C	-
RUMEX OCCIDENTALIS / WESTERN DOCK	123456789	A	-
RUPPIA MARITIMA / DITCH GRASS	123456789	A	-
SALICORNIA VIRGINICA / GLASSWORT OR PICKLEWEED	123456789	A	-
SCIRPUS AMERICANUS / THREE-SQUARE BULRUSH	123456789	A	-
SCIRPUS CERNUUS / LOW BULRUSH	123456	C	-
SCIRPUS MARITIMUS / SEACOAST BULRUSH	1234567	C	-
SCIRPUS VALIDUS / AMERICAN GREAT BULRUSH; TULE	123456789	A	-
SPARTINA ALTERNIFLORA / CORDGRASS	?	C	-
SPERGULARIA CANADENSIS / CANADIAN SAND SPURRY	123456789	C	-

KEY TO SYMBOLS 1.1.1 A-2

COMMUNITY COMPOSITION ESTUARY ZONE: INTERTIDAL HABITAT: EMERGENT VEGETATION

SCIENTIFIC NAME COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (1) PRODUCER VASCULAR PLANTS			
SPERGULARIA MACROTHECA BEACH SAND SPURRY	123456789	C	-
SPERGULARIA MARINA SALTMARSH SAND SPURRY	123456789	C	-
STELLARIA CALYCANTHA NORTHERN STARWORTS	1234567	C	-
STELLARIA HUMIFUSA SPREADING STARWORT	12345	U	R
TRIFOLIUM WORMSKJOLDII MARSH CLOVER	123456789	C	-
TRIGLOCHIN MARITIMUM SEASIDE ARROWGRASS	123456789	A	-
TYPHA LATIFOLIA CATTAIL OR SOFT FLAG	123456789	C	-
TROPHIC LEVEL: (2) HERBIVORE INVERTEBRATES			
ASSIMINEA CALIFORNICA SNAIL	123456789	C	-
LITTORINA SCUTULATA PERIWINKLE	123456789	C	-
TROPHIC LEVEL: (2) HERBIVORE BIRDS			
ANAS ACUTA PINTAIL	123456789	C	G
ANAS AMERICANA AMERICAN WIDGEON	123456789	A	G
ANAS CLYPEATA NORTHERN SHOVELER	123456789	C	G
ANAS CRECCA GREEN-WINGED TEAL	123456789	C	G
ANAS PENELOPE EUROPEAN WIDGEON	123456789	U	G
ANAS PLATYRHYNCHOS MALLARD	123456789	C	G
ANAS STREPERA GADWALL	123456789	U	G
ANSER ALBIFRONS WHITE-FRONTED GOOSE	123456789	U	G
BRANTA CANADENSIS CANADA GOOSE	123456789	U	G
CHEN CAERULESCENS SNOW GOOSE	123456789	U	G
FULICA AMERICANA AMERICAN COOT	123456789	C	G

SCIENTIFIC NAME COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (2) HERBIVORE BIRDS			
MELOSPIZA MELODIA SONG SPARROW	123456789	C	-
OLOR COLUMBIANUS WHISTLING SWAN	123456789	U	-
TROPHIC LEVEL: (2) HERBIVORE MAMMALS			
CASTOR CANADENSIS BEAVER	12345678	U	C
ONDATRA ZIBETHICA MUSKRAT	1234567	U	-
TROPHIC LEVEL: (3) CARNIVORE BIRDS			
ARDEA HERODIAS GREAT BLUE HERON	123456789	C	-
BUTORIDES STRIATUS GREEN HERON	123456789	U	-
TRINGA FLAVIPES LESSER YELLOWLEGS	123456789	C	-
TROPHIC LEVEL: (3) CARNIVORE MAMMALS			
PHOCA VITULINA HARBOR SEAL	123456789	U	-
TROPHIC LEVEL: (4) DETRITIVORE INVERTEBRATES			
ANISOGRAMMARUS CONFERVICOLUS PILL BUGS	23	[illegible]	-
GNORIMOSPHAEROMA OREGONENSIS PILL BUGS	279	C	-
MACOMA INCONSPICUA CLAM	123456789	A	-
MACOMA NASUTA BENT-NOSED CLAM	123456789	C	-
TROPHIC LEVEL: (5) OMNIVORE BIRDS			
CORVUS BRACHYRHYNCHOS COMMON CROW	123456789	C	-
STURNUS VULGARIS STARLING	123456789	U	-

COMMUNITY COMPOSITION ESTUARY   ZONE: INTERTIDAL

SCIENTIFIC NAME COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (5) OMNIVORE MAMMALS			
PEROMYSCUS MANICULATUS DEER MOUSE	123456789	C	-
PROCYON LOTOR RACCOON	123456789	C	C
SOREX TROWBRIDGII TROWBRIDGE SHREW	123456789	U	-
SOREX VAGRANS VAGRANT SHREW	123456789	A	-
TROPHIC LEVEL: (6) PARASITE VASCULAR PLANTS			
CUSCUTA SALINA SALT MARSH DODDER	123456789	C	-
TROPHIC LEVEL: (7) FILTER FEEDER INVERTEBRATES			
CRYPTOMYA CALIFORNICA SOFT-SHELL CLAM	123456789	A	-
MYA ARENARIA SOFT-SHELL CLAM	123456789	C	S
TROPHIC LEVEL: (8) SCAVENGER BIRDS			
HALIAEETUS LEUCOCEPHALUS BALD EAGLE	12345679	U	T
TROPHIC LEVEL: (9) INVERTEBRATE EATER INVERTEBRATES			
CRANGON ALBA WHITE SHRIMP	20	C	-
CRANGON FRANCISCORUM -NULL-	123456789	C	-
CRANGON NIGRICAUDA BLACK-TAILED SHRIMP	123456789	C	-
NEOMYSIS MERCEDIS MYSID SHRIMP	120	A	-
TROPHIC LEVEL: (9) INVERTEBRATE EATER BIRDS			
CALIDRIS ALPINA DUNLIN	123456789	C	-
CALIDRIS MAURI WESTERN SANDPIPER	123456789	U	-
CALIDRIS MINUTILLA LEAST SANDPIPER	123456789	C	-

HABITAT: EMERGENT VEGETATION

SCIENTIFIC NAME COMMON NAME	RANGE	ABUNDANCE	STATUS
TROPHIC LEVEL: (9) INVERTEBRATE EATER BIRDS			
CHARADRIUS VOCIFERUS KILLDEER	123456789	C	-
LIMNODROMUS GRISEUS SHORT-BILLED DOWITCHER	123456789	C	-
LIMNODROMUS SCOLOPACEUS LONG-BILLED DOWITCHER	123456789	C	-
NUMENIUS AMERICANUS LONG-BILLED CURLEW	123456789	U	-
NUMENIUS PHAEOPUS WHIMBREL	123456789	U	-
PLUVIALIS DOMINICA AMERICAN GOLDEN PLOVER	123456789	U	-
PLUVIALIS SQUATAROLA BLACK-BELLIED PLOVER	123456789	C	-
TRINGA MELANOLEUCA GREATER YELLOWLEGS	123456789	C	-
TROPHIC LEVEL: (9) UNKNOWN INVERTEBRATES			
OVATELLA MYOSOTIS BUTTON SHELL	123456789	C	-

APPENDIX C

ECONOMIC AND SOCIAL EVALUATION

APPENDIX C

ECONOMIC AND SOCIAL EVALUATION

TABLE OF CONTENTS

TABLE OF CONTENTS (con.)

TABLES

TABLE OF CONTENTS (con.)

FIGURES

EXHIBITS

SECTION 1. ECONOMIC AND SOCIAL ENVIRONMENT

1.01 Population Characteristics. Grays Harbor County population ranks 12th in Washington State and contains 1.6 percent of the state's population. Residents in the county numbered approximately 66,300 according to final counts from the 1980 U.S. Census of Population. The area remains lightly populated with a 1980 density of 35 persons per square mile, substantially below the state average of 62. Slightly more than half of the county population resides in the industrialized area in the eastern portion of the county, which includes the two largest cities, Aberdeen and Hoquiam, and the town of Cosmopolis.

a. Historic Population Growth. In the 45-year period from 1930 to 1975, the county population showed virtually no increase from the 59,982 total in 1930, as shown in table C-1. The lack of long-term growth during these years is in sharp contrast to statewide population which more than doubled from 1.56 million to 3.49 million. Since 1975, the county population has increased at an annual rate of nearly 2 percent, with most of the gain occurring in 1979-1980. This growth still lagged considerably behind the 3.4 percent average annual increase

TABLE C-1

POPULATION TRENDS OF WASHINGTON STATE, GRAYS HARBOR COUNTY, AND SELECTED CITIES

1930-1980

Year	Washington State	Grays Harbor County	Aberdeen	Hoquiam	Cosmopolis
1930	1,563,396	59,982	21,723	12,766	1,493
1940	1,736,191	53,166	18,846	10,835	1,207
1950	2,378,963	53,644	19,653	11,123	1,164
1960	2,853,214	54,465	18,741	10,762	1,312
1970	3,413,244	59,553	18,489	10,466	1,599
1975	3,493,990	60,200	18,067	10,054	1,600
1978	3,774,300	62,300	19,100	10,400	1,600
1979	3,911,200	63,700	19,075	10,400	1,605
1980	4,130,163	66,314	18,739	9,719	1,575
Percent Average Annual Growth Rate - Percent					
(1970-1980)	1.92	1.08	0.13	-0.74	-0.15
1975-1980)	3.40	1.95	0.73	-0.68	-0.31

Sources: U.S. Bureau of the Census; Washington State, Office of Financial Management

TABLE C-2

POPULATION OF GRAYS HARBOR COUNTY
1970-1980

	1970	1975	1976	1977	1979	1980	Percent Change 1975-1980
Grays Harbor County	59,553	60,200	60,500	61,400	63,700	66,314	10.2
Elma	2,227	2,470	2,470	2,452	2,750	2,720	10.1
McCleary	1,265	1,275	1,312	1,315	1,400	1,419	11.3
Montesano	2,847	2,790	2,790	2,790	2,850	3,247	16.4
Oakville	460	503	574	585	610	537	6.8
Aberdeen	18,489	18,067	18,980	18,900	19,075	18,739	3.7
Hoquiam	10,466	10,054	10,445	10,430	10,400	9,719	-3.3
Cosmopolis	1,599	1,600	1,600	1,590	1,605	1,575	-1.6
Westport	1,364	1,382	1,536	1,530	1,550	1,954	41.4
Ocean Shores	—	1,021	1,021	1,280	1,604	1,692	65.7
Unincorporated	20,836	21,038	19,772	20,528	21,856	24,712	17.5

Sources: U.S. Bureau of the Census; Washington State, Office of Financial Management.

in state population from 1975 to 1980. In recent years important population shifts have occurred within the county. Aberdeen and Hoquiam have actually lost population since 1976, while smaller outlying communities have grown significantly. The gains have been especially notable in the communities of Montesano, Elma, and McCleary in the eastern section of the county and in the ocean fishing and resort towns of Westport and Ocean Shores. Small, unincorporated rural towns within commuting distances of the Aberdeen-Hoquiam urban area also have registered sizable population gains since 1975 as shown in table C-2.

b. Projected Population Growth. The population of Grays Harbor County is projected to reach 70,300 by 1985, 73,000 by 1990, and 77,100 by the year 2000 as shown in table C-3. During the 1980-2000 period, the number of residents is projected to increase at an 0.8 percent average annual rate. The overall increase of 10.1 percent during the first decade is almost double the 5.6 percent gain over the 1990-2000

TABLE C-3

POPULATION FORECASTS FOR WASHINGTON STATE AND GRAYS HARBOR COUNTY, 1980-2000

	1980	1985	1990	1995	2000
Grays Harbor County	66,300	70,300	73,000	75,200	77,100
Washington State	4,130,163	4,619,000	5,090,200	5,557,600	6,023,800
5-Year Average Growth Rate - Percent/Year:					
Grays Harbor County	—	1.18	0.76	0.60	0.50
Washington State	—	2.26	1.96	1.77	1.62

Source: Washington State, Office of Financial Management, Forecasting Division, December 1979

period. County population is projected to grow slower than that for the state over the next two decades. Washington State population is projected to increase at nearly 2 percent per year between 1980 and 2000. State population will increase 23.2 percent to approximately 5.1 million by 1990 and by 18.3 percent between 1990 and 2000.

1.02 Employment and Income. Employment data for Grays Harbor County illustrates the transitional nature of the regional economy. Average annual employment during 1979 reached a new peak with 29,250 employed, a 9.5 percent increase over 1978 and 30.6 percent above the 1975 average

level. Employment dropped to approximately 28,000 in 1980, due mainly to a sizable downturn in lumber and wood products production. While employment levels have moved higher in recent years, unemployment rates have also remained substantially above those for the entire state, ranging from 12.4 percent in 1975 to 8.0 percent in 1976. In 1980, the county unemployment rate averaged 11.1 percent, well above the rates in the previous 4 years.

a. Historic Employment Patterns. County employment has traditionally relied heavily on the forest products industry - logging, sawmills, millwork, plywood, and pulp and paper products. Of the annual average 1980 civilian county employment of approximately 28,000 persons, about 26 percent were employed in manufacturing. with nearly 6,000 persons (83 percent of manufacturing personnel) employed by forest products companies (table C-4). Among wage and salary employees, forest product workers accounted for [illegible] percent of those employed, well below the ratios for the preceding [illegible] years. In contrast to manufacturing employment which has fluctuated annually due to the cyclical nature of the forest products industry, employment in the nonmanufacturing sector has increased steadily in the last decade. Since 1975, the number of wage and salaried employees in nonmanufacturing occupations increased by 50 percent to nearly 19,000 by 1980. This reflects primarily a fivefold climb in the number of construction workers and substantial gains in the trade and service sectors. In the 1975-1980 period, the ratio of nonmanufacturing jobs to all wage and salaried employment increased from 66 percent to nearly 73 percent while manufacturing employment dropped to less than 28 percent of the total.

b. Major Employment Industries. The period of 1975 into early 1979 marked a relatively high rate of employment growth for Grays Harbor, spurred by bouyant markets for lumber and wood products and the beginning of construction of twin nuclear generating plants at Satsop in the eastern part of the county. These were also generally favorable years for other regional economic sectors. However, as 1979 ended at least three of the region's basic economic sectors (lumber and wood products, tourism, and seafood) were confronting severe problems. National housing starts started a decline that continued into 1981, adversely affecting the demand for softwood lumber and other wood products. Tourism began to be affected by higher gasoline prices and by the eruptions of Mount St. Helens in 1980. Problems in the seafood industry also worsened as salmon runs continued to decline, causing a decline in commercial and sports fishing activities in the coastal areas. However, the overall economic slump and the resultant drop from peak employment levels in 1979 has been somewhat buffered by the growing work force at the Satsop nuclear generating project, where Washington Public Power Supply System (WPPSS) nuclear plants 3 and 5 are being built. Construction began in April 1977 and reached a work force of 4,000 in late 1980. The labor force at Satsop was originally expected to peak in late 1982 with an estimated 5,100 employees, which would make the project the region's largest single economic sector. However, severe financial

TABLE C-4

GRAYS HARBOR LABOR FORCE AND
ANNUAL AVERAGE EMPLOYMENT, 1975 AND 1980

	Employment		Percent	Percent of Total in
	1975	1980	Change	Category (1980)
Total Labor Force*	25,544	31,404	22.9	--
Employed	22,388	28,011	25.1	--
Unemployed	3,156	3,393	7.5	--
Wage and Salary Employed**	19,300	26,220	35.8	100.0
Manufacturing	6,620	7,230	9.2	27.6
Food and Kindred Products	360	420	16.7	1.6
Lumber and Wood Products	4,440	4,640	4.5	17.7
Paper and Allied Products	1,050	1,330	26.7	5.1
Machinery	320	350	9.4	1.3
Other	450	490	8.9	1.9
Nonmanufacturing	12,680	18,990	49.8	72.4
Construction	760	3,700	386.8	14.1
Transportation, Utilities, and Communications	920	1,100	19.6	4.2
Trade	3,790	4,670	23.2	17.8
Finance, Real Estate, and Insurance	500	710	42.0	2.7
Services and Miscellaneous	3,070	4,470	45.6	17.0
Government	3,640	4,340	19.2	16.5

*By place of residence
**By place of employment

Source: Washington State Department of Employment Security, April 1981.

problems have beset the construction of WPPSS nuclear plants 4 and 5 and one of the twin plants at Satsop (number 5) will not be completed. The future employment picture is not clear at this time, but the halt of construction on plant 5 will definitely result in a loss of jobs. In effect, most of the county employment growth in 1978-1979 was spurred by construction of plants 3 and 5 and the subsequent multiplier effects of plant construction on the trade and service sectors.

c. Historic Income Growth. Approximately 45 percent of personal income in Grays Harbor is directly related to the forest products industry. This key regional industry accounted for 86 percent of all manufacturing payrolls and for an estimated 25 percent of the wages and salaries paid in nonmanufacturing sectors other than agriculture and government in the January-September 1980 period. While manufacturing and the forest products industry continue to be the dominant employment sector in the county, various nonmanufacturing sectors are steadily assuming greater importance in the economic balance. For all employees covered by the Washington State Employment Act, manufacturing payrolls totaled $107 million or 34 percent of total wages and salaries for all sectors in the first 9 months of 1980. Disbursements reported by forest products firms amounted to $91.4 million, 29 percent of the total for all economic sectors. Construction employment generated a $66.2 million payroll, the largest total for any single sector, followed by wholesale and retail trade ($34.7 million); services ($35.8 million); and transportation, communication, and utilities ($16.6 million). The combined value of payrolls in these four nonmanufacturing sectors amounted to $153 million, approximately 49 percent of all wages and salaries. Over the last 10 years, personal incomes reported for these nonmanufacturing sectors have been increasing steadily compared to uneven growth in manufacturing payrolls that are heavily dependent on the fortunes of the forest products industry (table C-5). The traditional dependence of the Grays Harbor economy on the fluctuating demand for forest products has resulted in both chronic high unemployment and lower than average personal incomes. In 1979, the latest year for which data is available, Grays Harbor accounted for 1.6 percent of all incomes in the State of Washington, a ratio that has remained relatively the same in recent years. During the 1973-1979 period, personal incomes of county residents increased at an average annual rate of 12.8 percent compared to a 13.5 percent growth rate for the entire state. In terms of per capita income, the $9,127 reported for Grays Harbor residents compared to $9,531 per state resident in 1979. During 1973-1979, per capita income in the county fluctuated from a low of 88 percent in 1975 to a high of 96 percent of state per capita income.

d. Projected Employment Growth. Projections of future employment in Grays Harbor County depend to a large extent on the realization of projects currently in inital or advanced planning stages. Employment in the basic forest products industry is expected to decline gradually over the next two decades, while other manufacturing activities and nonmanufacturing sectors are expected to attract more employees. Employment in fishing and agriculture is also projected to decrease at a slow rate,

TABLE C-5

WAGES AND SALARIES PAID IN GRAYS HARBOR COUNTY,
BY INDUSTRY SECTOR, 1971-1980
(Thousands of Dollars)

Industry	1971	1973	1975	1977	1980[1]
Total[2]	$118,899	$152,589	$165,021	$242,900	$314,324
Agriculture, Forestry, Fisheries	574	1,029	1,347	2,398	2,088
Mining	15	—	67	—	1,098
Construction	10,445	10,303	11,205	23,648	66,189
Manufacturing	61,005	79,484	80,864	121,306	106,611
Food and Kindred Products	2,832	2,645	3,204	3,944	3,654
Lumber and Wood Products	39,658	54,152	52,979	80,796	65,762
Paper and Allied Products	12,477	15,318	15,297	25,216	25,634
Printing and Publishing	844	841	843	1,029	1,033
Stone, Clay, Glass Products	373	416	386	575	537
Nonelectrical Machinery	3,359	3,899	4,621	5,427	5,670
Transport Equipment[3]	N/A	N/A	375	913	936
Other Manufacturing	1,462	2,213	3,159	3,405	3,385
Transportation, Communication, and Public Utilities	6,924	9,759	10,073	14,836	16,590
Trade, Wholesale, and Retail	19,607	24,348	27,772	36,507	34,704
Finance, Insurance, and Real Estate	3,074	3,691	4,027	5,633	6,084
Services	7,482	14,188	17,792	24,999	35,831
Government	9,771	9,774	11,875	13,573	45,128

1/January-September 1980 data.
2/Industry totals may not add to annual totals due to rounding.
3/Not separately identified in 1971-1973.

Source: Washington State Department of Employment Security, May 1981.

but this could be reversed by developing the potentials offered by the 200-mile fishing limit, namely increased operations involving the har-vesting and onshore processing of bottom fish. The potential for devel-opment of other industrial sites in the Grays Harbor estuary, possibly for coal, grain, or chemical export terminals, could further diversify and expand manufacturing employment. Depending on the nature and extent of these future developments, there could be a range of 200 to 5,500 new jobs created. The scheduled completion of one of the Satsop nuclear plants by 1985 and the mothballing of the second plant will result in a drop in construction employment, so the realization of estuary economic development potential is significant since similar construction skills are involved. Among the other sectors, employment in trade and service occupations is expected to continue on an uptrend, especially if off-season tourist trade and convention business is expanded. The overall employment forecast for 1990 assumes that (1) the shipping channel will be widened and deepened to accommodate larger, deep-draft ocean cargo vessels; (2) additional industrial sites will be acquired and developed; (3) the seafood industry will be stimulated by the potentials of the 200-mile fishing limit; and (4) tourist trade will be revived and relevant facilities expanded. Projected employment forecast for Grays Harbor by 1990, based on these assumptions, is indicated in table C-6.

1.03 Economic Activities. The economic development of Grays Harbor County has been historically tied to the region's timber resources, and the economic base of the cities has been their position as manufacturing and rail-water centers for shipping forest products to domestic and international markets. Next in importance are the diversified seafood and cranberry processing industries, together with a substantial tourist

TABLE C-6

BALANCED ECONOMIC DEVELOPMENT EMPLOYMENT FORECAST
GRAYS HARBOR, 1990

Sector	Total Employment 1980	Total Employment 1990	Percent Change 1980-1990
Manufacturing	7,230	8,773	21.3
Construction	3,700	1,271	65.6
Transportation and Utilities	1,100	1,618	47.1
Trade	4,670	6,512	39.4
Finance, Insurance, and Real Estate	710	855	20.4
Services	4,470	5,882	31.6
Government	4,340	4,927	13.5
Agriculture and Other	1,791	3,954	20.8
TOTAL	28,011	33,792	20.6

SOURCE: Grays Harbor Regional Planning Commission, May 1981.

industry for the recreational beaches and sport fishing activities. The area also has extensive ship supply services, ship and boatbuilding and repair, and related services. In view of the cyclical nature of the regional economy, future growth will require the continued development of basic sectors: forest products, tourism, seafood products, agriculture, and further diversification into other types of manufacturing operations.

a. Land Ownership. While the basic forest products industry relies heavily on Grays Harbor County, it also derives a high percentage of logs for processing or shipment from a much larger tributary area covering portions of Pacific, Jefferson, Lewis, and Clallam Counties. Products from the forest industry in the area include lumber, plywood, paper, chips, and furniture in addition to logs for export. Of the approximately 1.9 million acres identified as commercial forest land in the multicounty area tributary to Grays Harbor, 40 percent is owned by major forest industry companies. The remaining acreage is owned by Federal, state, and county agencies (28 percent); small lumber companies and individuals (23 percent); and Indian tribes (9 percent). Annual timber harvest by source of ownership varies by percent share on a year-to-year basis. According to historical data, cuttings from private lands generally account for at least half of the harvest with most of the remainder from Indian and national forest lands.

b. Forestry. Approximately 20 percent of employment in the forest products industry is with pulp and paper firms. The largest subsector is logging and logging contractors, accounting for approximately one-third of the total forest products employment, owing in large part to the high proportion of logs shipped to export markets. Sawmills and planing mills account for about 30 percent and millwork and plywood firms for the remaining 20 percent of forest products employment. In terms of wages and salaries, pulp and papermills account for 22-25 percent of the industry total, a higher proportion relative to employment than for lumber and wood products firms. In 1979, forest products employers paid one-third of total wages and salaries covered by state employment security provisions in Grays Harbor County. The major market for processed forest products is the national housing construction industry, subject to cyclical patterns that affect the demand for forest products directly. Overall national lumber production, while highly cyclical, has not increased significantly since 1950. National production of 38 billion board feet in 1950 compares with 38.7 billion board feet in 1977. Production in 1978-1979 averaged 37.4 billion board feet and dropped substantially lower in 1980 to an estimated 32 billion board feet, reflecting depressed housing markets and the national economic slowdown continuing into 1981. There are also two localized situations affecting the industry in the Grays Harbor region. Limited supplies of cedar are preventing growth in the shake and shingle subsector, a significant portion of the region's industry. Also, many of the area mills need replacing with modern, more efficient processing facilities, a shift that is expected to accelerate in the future providing adequate

sites are available. Pulp and paper production, on the other hand, has increased annually in a fairly consistent pattern and this trend is forecast to continue if adequate water supplies are available and water quality requirements can be met.

c. Forest Products Exports. In contrast to cyclical domestic markets, shipments of logs and lumber to foreign markets have become increasingly important to Grays Harbor. Log exports to Japan, and more recently to Korea and China, over the last 10 years have moved to generally higher levels. Overseas log shipments amounted to 487.6 million board feet Scribner (MMBF) in 1980 according to Port of Grays Harbor data, down from the peak of 629 MMBF in 1979. During the 1975-1980 period, log exports averaged 502 MMBF annually, compared to an average annual volume of 400 MMBF during 1970-1975. According to U.S. Forest Service reports, Grays Harbor accounts for 20-25 percent of the total log exports from the state. Lumber exports, primarily to Japan, have increased sharply in the last decade, averaging 52.8 million board feet during 1970-1975 and climbing to 94.7 million board feet annually during 1976-1980, reaching a record 130.5 million board feet in 1979. This favorable trend indicates a significant economic development potential that may have long-term implications on the structure of the forest products industry in the region.

d. Tourism. The tourist industry of the Grays Harbor area is based on the recreational aspects of the ocean beaches and sports fishing, particularly chartered salmon fishing out of Westport at the mouth of Grays Harbor. Ocean Shores has extensive recreation and housing facilities to accommodate a growing volume of tourists, clam diggers, and permanent residents. Westport, on the other hand, is a major state sport and commercial fishing center. During the 1973-1978 period, the volume of visitors to the ocean beaches increased at an annual average of 30 percent and to all state parks in the county by 9.5 percent. The volume of visitors to Westport peaked in 1976-1977 before a series of setbacks that have adversely impacted charter and commercial fishing activities. The biggest problem has been the dwindling salmon stocks leading to smaller catch limits and shorter fishing seasons. Rising fuel costs have also seriously affected the tourist trade and the costs of operating fishing vessels. Charter business dropped substantially in 1979-1980 and prospects for the immediate future are not favorable unless bottom fishing can attract more tourists. The area has significant potential for tourism growth, although at a lower rate than projected several years ago, by promoting off-season visits, developing convention facilities at Ocean Shores, improving highway access to the ocean beaches, and developing charter fishing for other than salmon.

e. Agriculture. In 1954, approximately 118,000 acres, or almost 10 percent of Grays Harbor County land, was utilized for farming. By 1974 there was a 58 percent decrease to 49,000 acres, or 4 percent of the county land area. The amount of cropland harvested and pastured

decreased by nearly one-third, from 39,000 acres to 26,000 acres over the same period. Also, the number of commercial farms decreased from 527 in 1954 to 229 in 1974. Neighboring counties experienced similar decreases during this period. The 1978 Census of Agriculture, however, indicated this downward trend has been reversed with a small increment in overall farm acreage, including an 8 percent increase in cropland to 29,000 acres. While the total number of farms continued down, the number of commercial farms with sales of $2,500 or more rose to 254 occupying 42,400 acres. Of these, 89 reported annual sales of $20,000 or more. The value of all farm products in the county totaled $13.8 million in 1978 compared to $10.1 million in 1974. Approximately 90 percent of the value represented sales of livestock products, primarily dairy items. Among cropland products sold commercially, green peas, potatoes, melons, and silage corn are predominant. Dairy products continue to account for the major share of gross farm receipts in the county, increasing from a 52 percent share in 1954 to 70 percent in 1978. Crop sales accounted for one-fourth of receipts in 1954 but have fallen to about 10 percent of the total. This pattern could be reversed as indicated by a sizable 17 percent increase in harvested cropland acreage during the 1974-1978 period. The cranberry industry, which requires conditions of climate and soils found in the southwest section of the county, has remained relatively stable in recent years. The small number of growers have fluctuating annual yields, but favorable market conditions based on a seasonal demand for this item are assured in the future. There is potential for expanded production of specialty crops such as mushrooms, berries, peas, corn, bulbs, and Christmas trees. These are crops suitable for the adequate moisture and long growing seasons in the area and the proximity of Grays Harbor to the large urban markets in Portland and around Puget Sound.

f. Fisheries. The income generated from the region's fishery resources constitutes a significant part of the Grays Harbor economic base. The most prominent seafood item is anadromous salmon which spawn in the creeks, rivers, and streams of the county and other tributary areas. Other commercially harvested seafood includes crabs and oysters from the estuary, beach clams, and shrimp, tuna, and bottom fish from the sea. In the last 14 years, however, a notable shift has occurred in both the volume of salmon and shellfish catch and the Grays Harbor district share of state seafood landings. In 1966 the 6.3 million pounds of salmon for the district accounted for 19.4 percent of the state total. By 1975, with interim year fluctuations, the 6.5 million pound salmon catch accounted for 14.4 percent of the state volume, showing a fairly consistent share decrease. The share of Grays Harbor shellfish landings of the state total also dropped during 1966-1975, from 39 percent to 25 percent, peaking in 1969 with half of the state shellfish catch. The 24.4 million pounds of total seafood catch for Grays Harbor in 1975 had a landed value of approximately $11 million. During the 1976-1980 period, the average annual landed poundage of all seafood declined by 8 percent to 22.5 million pounds with an average annual value of about $10.8 million. Over these 5 years, the salmon catch averaged slightly

above 3.7 million pounds, substantially below the average annual yield since the mid-1960's. On the other hand, the landed volume of bottom fish such as rock fish, sole, and ling cod and other food fish has increased substantially in recent years, averaging 16.3 million pounds annually in 1976-1980 compared to an average of 7.3 million pounds per year during the 1970-1975 period. While the salmon and shellfish catch has either declined or leveled in recent years, the harvest of bottom and other food fish, including tuna, is increasing and through 1980 has compensated in large measure for the diminishing salmon and shellfish catch. Future prospects for a healthy seafood industry in the Grays Harbor area will depend on the further growth of bottom fishing to take advantage of the 200-mile fishing limits, the expansion of on-shore processing facilities, and a further reduction in commercial and charter salmon fleets until salmon runs improve in the future.

g. Port Activities. The Port of Grays Harbor reported a record year in 1979, moving nearly 4.2 million short tons in waterborne commerce. Included were 3.9 million tons of logs and lumber, a peak year for these forest products; 173,000 tons of wood chips; and 4,000 tons of general cargo. Waterborne tonnage moving through the port in 1980 declined by 22 percent to approximately 3.3 million short tons due almost entirely to a sizable decrease in outgoing shipments of logs and lumber. Over the 1976-1980 period, total annual tonnage moving through the port averaged nearly 3.4 million tons compared to an average of approximately 2.9 million tons during 1970-1975. This significant growth in port tonnage primarily reflects a strong general uptrend in export loadings of logs and lumber over the last decade. Future growth of waterborne commerce moving through the port will depend on a variety of factors including world demand, improvements to the navigation channel, adequate industrial land, and diversification of the export base.

SECTION 2. ECONOMIC EVALUATION

2.01 Methodology. Economic evaluation of the proposed channel improvements was conducted in accordance with the Principles and Standards Procedures for National Economic Development (NED) benefit evaluation of deep-draft navigation projects, as published in the Federal Register, Volume 45, Number 190, dated 29 September 1980. The basic economic benefits from the proposed Grays Harbor widening and deepening project are the reduction in the cost required to transport forest products from Grays Harbor to destination ports. Specific transportation savings result from economies of scale which in turn result from using larger vessels and using existing vessels more efficiently. If there is no change in either the origin or destination of a commodity, the benefit is the difference in the cost of transporting the commodities, with and without the proposed improvements.

a. Principal Commodities. The major commodities shipped from Grays Harbor are logs, lumber, and woodchips. Pulp is manufactured in Grays Harbor, but is generally trucked to other ports for shipment. The two pulp mills in the harbor do not produce in sufficient quantity to justify a vessel port of call. A few minor commodities such as fuel oil and liquid lignin are also shipped to and from the harbor, but in quantities and vessels that would be unaffected by the proposed improvements. The Port of Grays Harbor has been very aggressive in trying to attract new commodities to the port. In 1981, the port commissioned feasibility studies for a large export coal and grain terminal located in the South Shore Industrial area. The studies have shown the proposed site could accommodate a terminal with an annual throughput of 10 million tons of coal and 3 million tons of grain. Other efforts have been directed toward a smaller terminal that can handle a range of commodities such as spot shipments of coal, woodchips, sulphur, bentonite, and talc. A study is underway to determine the feasibility of converting Terminal 2 from a wood products terminal to a diversified bulk cargo terminal. Terminal 2 has a 600-foot pier of reinforced concrete built in 1979, a 72-acre backup for open storage, a new 50,000-square-foot warehouse for covered storage, and a nearby tank farm. The port figures the cost of its diversified commodity terminal at perhaps $9 million versus at least $50 million to compete with the large specialized coal terminals at the Ports of Portland and Kalama. Although new commodities look to be a definite part of the future in Grays Harbor, the commodity types and volumes, as well as vessels used to transport them, are unknown at this time. Accordingly, no benefits were claimed for induced commodity movements. Forecasts of log, lumber, and woodchip exports are for the time period 1990 to 2040, and presented in summary form in the following paragraphs and in detail in exhibit 1.

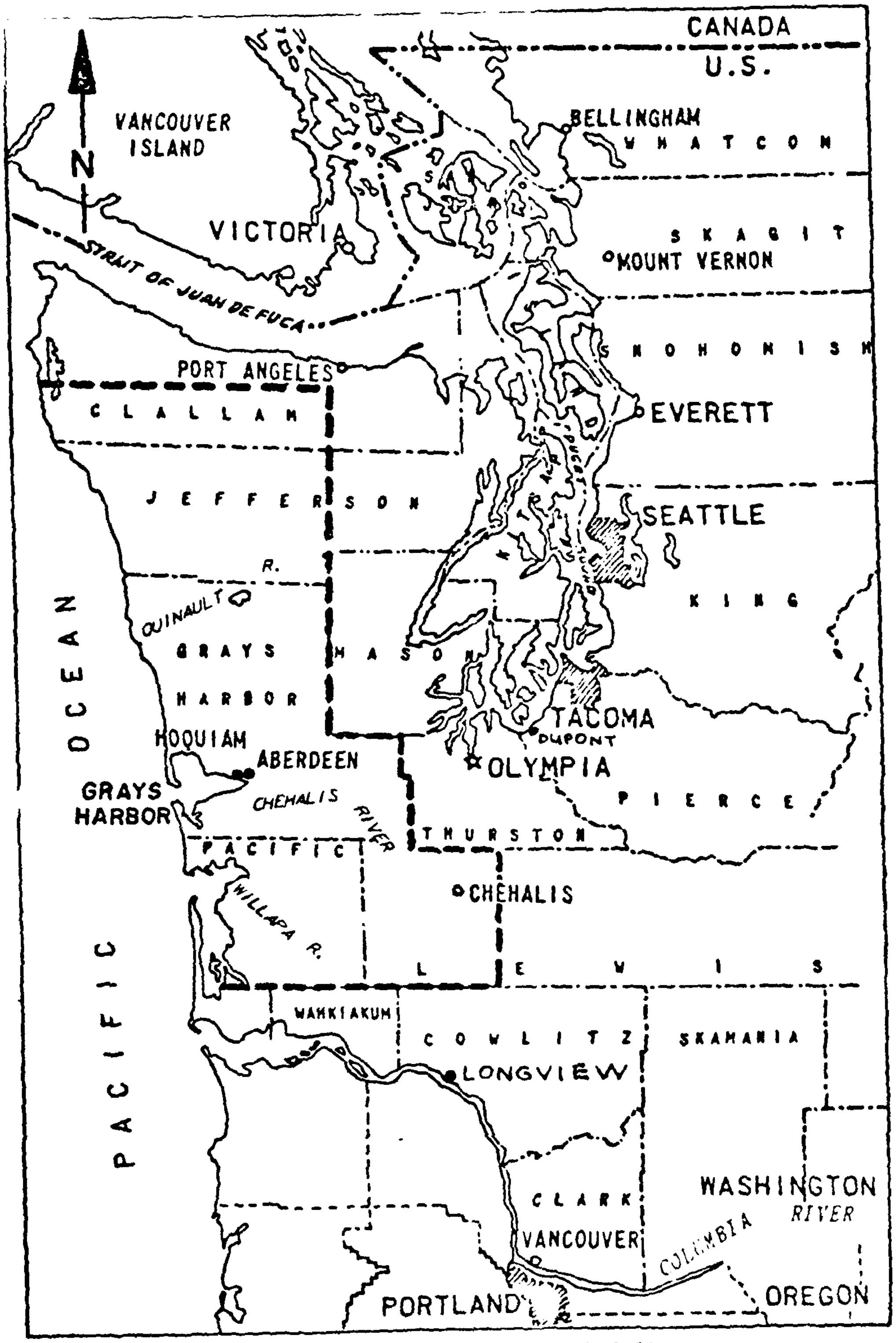
b. Without-Project Condition. The without-project condition is the most likely condition expected to exist over the planning period (i.e., 1990-2040) in the absence of the plan, including any known change

in law or public policy. For benefit estimating purposes, the without-project condition was assumed to be a 30-foot-deep navigation channel, (measured at M.L.L.W) which is the presently authorized depth in Grays Harbor.

c. With-Project Condition. The with-project condition is the one expected to exist over the period of analysis if the project is undertaken. Benefits attributable to the proposed channel improvements are equal to the difference in total transportation costs with and without the project. Transportation savings in Grays Harbor were based on the incremental reduction in transportation costs between those assumed to exist at a channel depth of -30 feet and those at successive 1-foot increments of a deeper channel, down to -45 feet. For example, transportation savings at -35 feet were equal to the transportation cost per ton at -30 feet minus the similar cost at -35 feet. This increment of savings was then multiplied by annual forecasted tonnage to get average annual benefits.

2. Economic Study Area. The economic study area that is tributary to the proposed channel improvements in Grays Harbor is defined as all of Pacific and Grays Harbor Counties, the western half of Jefferson and Lewis counties, and the southwestern corner of Clallam County. Figure C-1 shows a map of the tributary area. A detailed description of this area, with emphasis on Grays Harbor County, is in section 1 of this appendix. The commodities being shipped into and out of Grays Harbor include logs, lumber, woodchips, general cargo, and petroleum products. In 1980, logs, lumber, and woodchip exports totaled 3,236,476 short tons or 99 percent of total tonnage of 3,281,225 short tons. All of the logs, woodchips, and 66 percent of the lumber were exported to Pacific Rim countries, mainly Japan. The Pacific Rim countries are shown in figure C-2.

o Alternative Ports. Alternative ports which are within trucking distance from Aberdeen are Tacoma (77 miles away) and Longview (95 miles away). The Weyerhaeuser Company is proposing to build a deep-draft shipping port at Dupont, which is approximately 65 miles from Aberdeen, but Weyerhaeuser officials have emphasized that they expect no significant shift of export volumes from Grays Harbor when the Dupont facility is constructed sometime in 1983 or 1984. (Weyerhaeuser Export Facility at Dupont, Volume I, Final Environmental Impact Statement, page 211.) Any diversion of Weyerhaeuser cargo to the Dupont facility is more likely to come from their Tacoma shipping operations, which are only about 12 miles from Dupont compared with 65 miles from Aberdeen. The biggest advantage Tacoma and Longview have over Grays Harbor, in terms of deep-draft shipping, is their deeper navigation channels which allow larger, more cost effective vessels to call. Authorized channel depths at Grays Harbor, Tacoma, and Longview are -30 feet, -35 feet, and -40 feet, respectively. Evidence of the impact of a relatively shallow channel can be seen by looking at the change in the market share of logs, lumber, and chip exports over time. In 1970, Grays Harbor exported

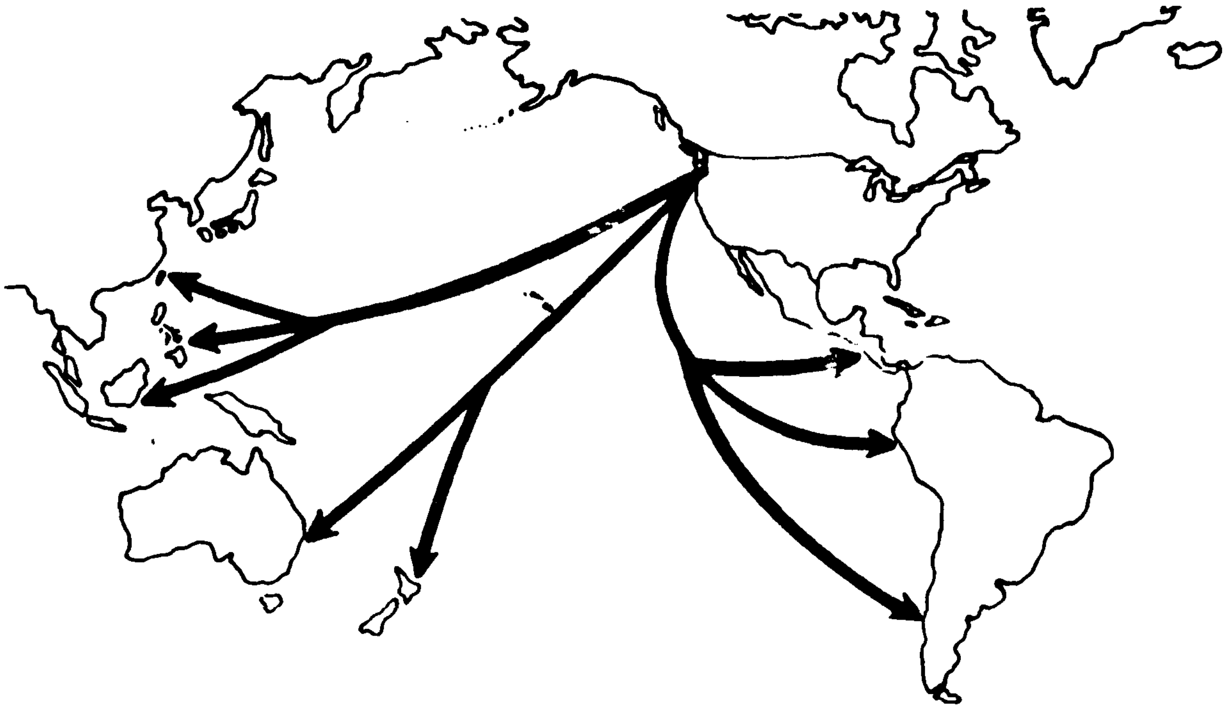


TRIBUTARY AREA
GRAYS HARBOR, WASHINGTON

FIGURE C-1

NORTHWEST FOREST PRODUCTS EXPORTS TO THE PACIFIC RIM

- The Pacific Northwest Exports a Wide Variety of Forest Products to Pacific Rim Countries. This Region Is Expected to Show Moderate to Strong Economic Growth in the 1980s and 1990s. Thus the Northwest Will Be in a Key Position to Help Meet Growing Needs for Wood and Paper Products in the Pacific Basin



THE NORTHWEST EXPORTS FOREST PRODUCTS TO THESE PACIFIC RIM COUNTRIES

China – Pulp, Containerboard, West Coast Logs, Lumber
Hong Kong – Pulp, Lumber, Containerboard
Indonesia – Pulp, Paperboard, Containerboard
Japan – Pulp, Paperboard, Lumber, Containerboard, Plywood Chips, Secondary Fiber, West Coast Logs, Newsprint Other Products
Malaya – Pulp, Containerboard, Paper
Philippines – Pulp, Paper, Containerboard
Korea – Pulp, Paperboard, Containerboard, Secondary Fiber West Coast Logs
Taiwan – Pulp, Containerboard, Secondary Fiber
Thailand – Pulp, Containerboard, Secondary Fiber
Australia – Pulp, Paperboard, Paper, Lumber, Plywood
New Zealand – Pulp
Fiji Islands – Pulp

Mexico – Pulp, Paperboard, Paper, Containerboard, Ship Container, Secondary Fiber
Costa Rica – Paperboard, Containerboard
El Salvadore – Pulp, Containerboard
Guatamala – Containerboard
Honduras – Containerboard
Nicaragua – Pulp
Panama – Pulp, Paperboard, Paper
Argentina – Pulp
British Honduras – Paperboard
Brazil – Pulp, Ship Containerboard
Columbia – Pulp
Ecuador – Pulp, Paperboard, Containerboard
Peru – Pulp, Lumber
Venezuela – Pulp, Paperboard

FIGURE C-2

40 percent of the three-port total, compared with 27 percent for Longview, and 33 percent for Tacoma. By 1978, Grays Harbor's share had droped to 31 percent, versus 33 percent for Longview, and 36 percent for Tacoma. Yet, Grays Harbor is at least 12 hours closer to Japan than either Tacoma or Longview; some of the best Hemlock and Douglas fir timberlands are tributary to the Port of Grays Harbor (see exhibit 1, section 1); and all three ports charge comparable user fees. The proposed widening and deepening of the Grays Harbor channel is, therefore, not seen as capable of diverting forest products tonnage from these two competitive harbors. The project will give Grays Harbor a channel depth more comparable to what these other two ports already have. More likely, the proposed improvements would enable Grays Harbor to sustain its present market share of log, lumber, and chip exports among the three ports and possibly compete more effectively for new port business, as compared with the without project condition. Benefit calculations, therefore, assumed that channel deepening would not divert forest products tonnage from either Longview or Tacoma.

2.03 Existing and Projected Commodity Flows. As discussed earlier, log, lumber, and woodchip exports accounted for 99 percent of total waterborne commerce in Grays Harbor in 1980. The ensuing analysis concentrates on these three commodities because they will specifically be affected by the proposed project and because they practically account for total commerce in the harbor. A detailed analysis of existing and projected log, lumber, and woodchip exports is contained in exhibit 1. The following paragraphs present summary information extracted from the exhibit.

a. Logs. Log exports have historically been the economic mainstay of Grays Harbor. Total volumes of log exports for the period 1961 to 1980 are shown in figure C-3. Exports rose rapidly during the period 1962 to 1968, but the growth rate slowed from 1968 to 1980. Major drops in exports volumes occurred in 1971, 1974, and 1975. The low in 1971 was caused by a dock strike, and the lows of 1974 and 1975 resulted from distortions to the Japanese economy caused by rapidly increasing energy costs. Volumes ranging from 2.7 million to 2.8 million short tons were reached in 1972, 1973, 1976, 1978, and 1980, with the average tonnage in these 6 years at approximately 2.7 million short tons. The highest log export volume occurred in 1979 with 3.6 million short tons. Census data shows that in 1979 log exports were 4.8 percent of total major commodity exports for the United States, 25.3 percent for the Pacific Coast, 34.4 percent for the Pacific Northwest, 48.4 percent for the State of Washington, and 90.4 percent for Grays Harbor. As the geographical area is condensed and focused on Grays Harbor, log exports as a key commodity in foreign exports change in importance from relatively insignificant at the national level to total dominance at the Grays Harbor level. Nineteen percent of total United States log exports in 1979 were shipped from Grays Harbor.

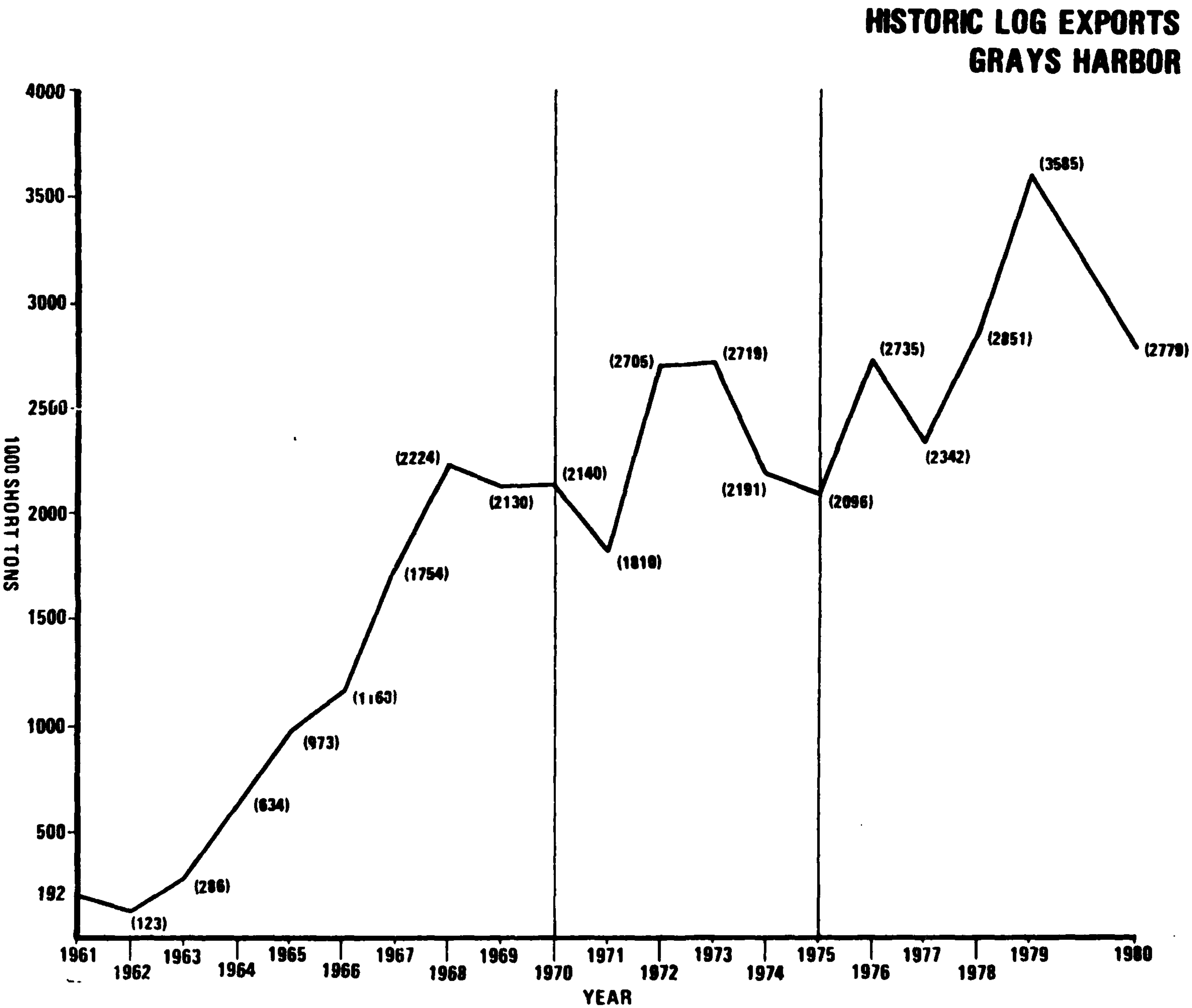

HISTORIC LOG EXPORTS
GRAYS HARBOR
1000 SHORT TONS
4000
3500
3000
2500
2000
1500
1000
500
192
(123)
(286)
(634)
(973)
(1163)
(1754)
(2224)
(2130)
(2140)
(1810)
(2705)
(2719)
(2191)
(2096)
(2735)
(2342)
(2851)
(3585)
(2779)
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
YEAR

FIGURE C-3

(1) Market Analysis - Logs. All logs exported from Grays Harbor go to the Orient, mainly to Japan but also to South Korea and China. Japan is expected to remain the dominant customer for logs, lumber, and woodchip exports originating in the Grays Harbor tributary area. Accordingly, projected levels of Grays Harbor forest product exports are expected to be directly but not exclusively related to future Japanese consumption levels. Markets in China and other Pacific Rim countries (see figure C-2) have enormous growth potential and are just beginning to develop. Some forest products (mainly lumber) are also exported from Grays Harbor to the Mediterranean. The majority of logs exported to South Korea are processed into lumber and then exported to Japan. As a result, future levels of South Korean demand for log exports from Grays Harbor are also expected to be strongly tied to future Japanese timber consumption patterns.

(2) Historical Japanese Forest Products Demand. Historically, Japan has imported large volumes of logs rather than finished lumber from the United States. Thousands of family-owned Japanese sawmills process logs into hundreds of sizes that are unique to Japanese residential construction methods. In 1978, approximately 69 percent of United States world log exports were sold to Japan. This was due to the price competitiveness of United States softwood logs versus the price of competing Japanese species. Japan also imported approximately 30 percent of total United States finished lumber exports to the world over the period 1975 through 1978. United States world lumber export levels remained relatively stable over this period, as a strong domestic United States demand maintained a level of higher prices and, therefore, reduced the incentive to sell to foreign export markets. The demand for housing is the primary driving force behind Japanese demand for softwood logs and finished lumber. Approximately 77 percent of sawn lumber consumed in Japan is used in housing construction, so fluctuations in Japanese lumber and plywood demand patterns closely parallel changes in the number of new housing starts.

(3) Projected Log Exports. Projections of log exports from Grays Harbor were developed from the time of the study (1981) to the end of the period of analysis (2040). The economic life of the proposed project was assumed to be 1990 to 2040. Four independent studies dealing with projected log exports from Washington and/or Grays Harbor have been conducted since 1975: (1) the 1975 Port System Study, (2) the 1980 Port System Study, (3) the 1977 Forest Tributary Study, and (4) the 1981 Forest Policy Project. Log export forecasts from each of these studies were analyzed and evaluated in terms of their major assumptions and forecasting methodologies. Supplemental forecasts used for comparison purposes were provided by the 1976 Grays Harbor Interim Feasibility Study and by a regression analysis based on historical log exports. These alternative forecasts are summarized in graphical form in figure C-4. Extensive personal interviews with principals of the seven major forest products and trading companies in Grays Harbor were conducted to obtain a consensus of future trends in forest products exports.

ALTERNATIVE LOG EXPORT FORECASTS
GRAYS HARBOR

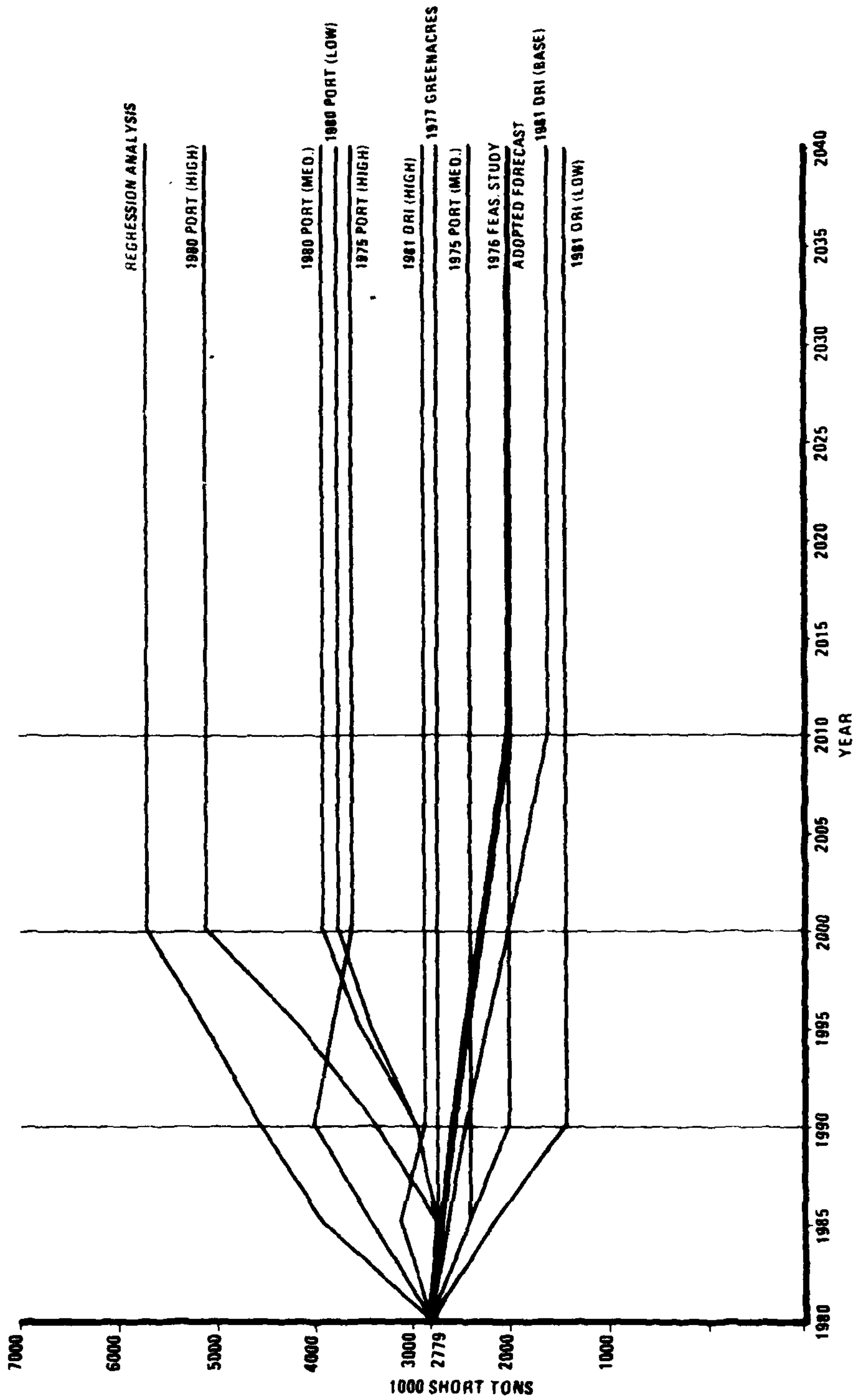


FIGURE C-4

Finally, pertinent articles in newspapers and relevant trade journals were researched for any insights they could provide on future log exports in particular, and on future forest projects exports in general. This was especially helpful in evaluating the market in China, where industry experience is very limited.

(4) Adopted Log Export Forecast. Based on a thorough analysis and evaluation of the alternative log export forecasts, their underlying assumptions, and industry opinion, the adopted forecast of log exports to Japan was the base case forecast prepared for the 1981 Forest Policy Project by the consulting firm of Data Resources Inc. (DRI). This forecast was more representative of projected declines in housing starts, household formation, and overall timber demand in Japan than the other forecasts. One problem with the DRI Forecast was that it did not include demand by China, which already is and will continue to be an important log export market for Grays Harbor. Accordingly, the DRI forecast was augmented by a forecast of log exports to China, the latter being well within the range of current exports to China. The adopted forecast is summarized in table C-7 and shown in figure C-4.

TABLE C-7

ADOPTED LOG EXPORT FORECAST
(Thousands of Short Tons)

Year	Japan	China1/	Total
1980 (Actual)	2,625	175	2,800
1990	2,400	200	2,600
2000	2,000	300	2,300
2010	1,600	400	2,000
2040	1,600	400	2,000

Average Annual Equivalent: 1990-2010 : 2,400
2010-2040 : 2,000
1990-2040 : 2,300

1/Log exports to China totaled 554,000 short tons from January through October, 1981.

b. Lumber. The total volume of lumber shipped from the Port of Grays Harbor during the period 1970 through 1980 is shown graphically in figure C-5. The data shows that total lumber shipments more than doubled between 1970 and 1980, with one very high volume year in 1979. This sharp increase in lumber shipments has been the result of the development of export markets, since domestic shipments have remained relatively steady, averaging 89,000 short tons per year over the same 10-year period. Although lumber exports have grown rapidly at Grays Harbor, they still represent a relatively small proportion of total

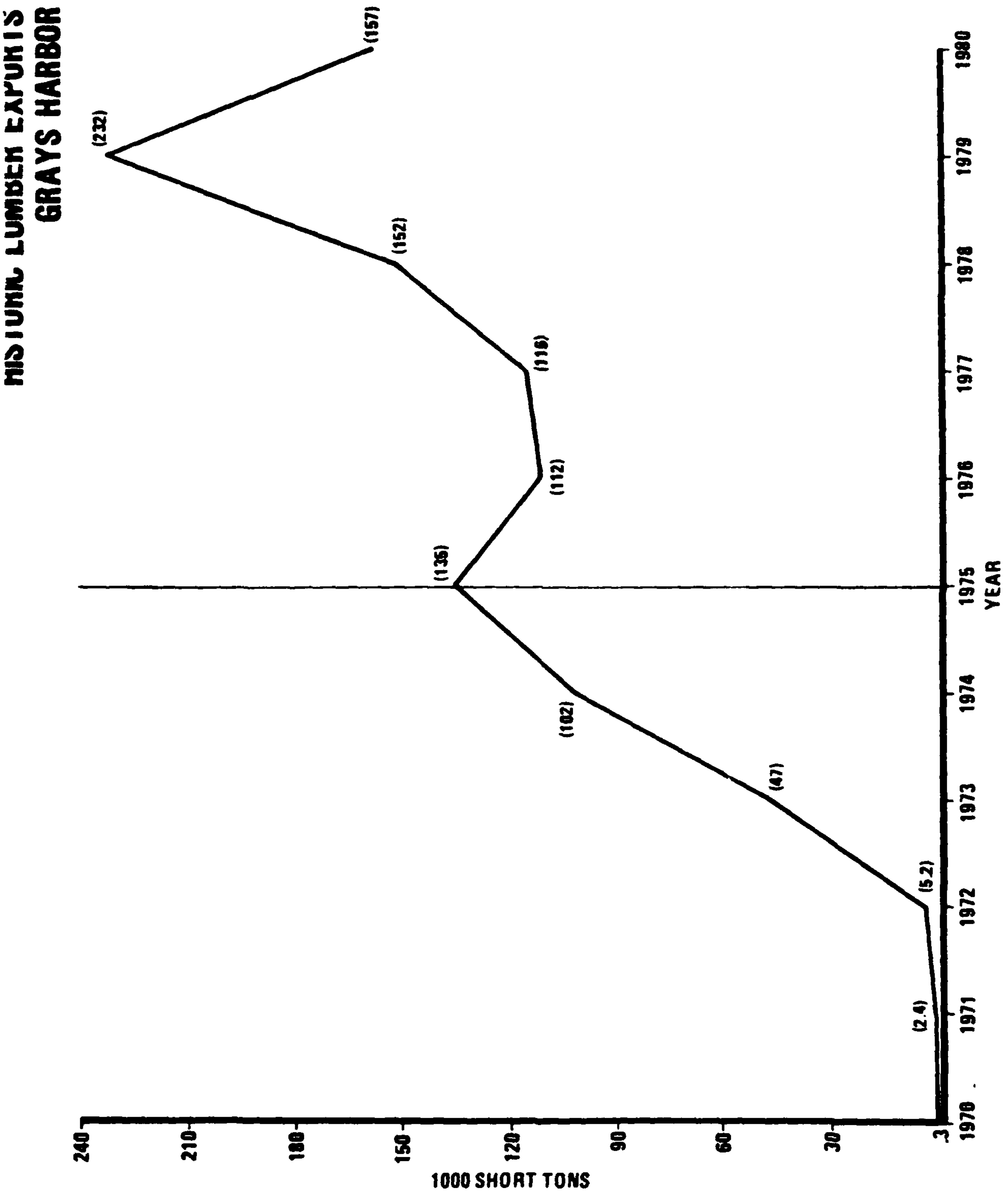

HISTORIC LUMBER EXPORTS
GRAYS HARBOR
1000 SHORT TONS
240
210
180
150
120
90
60
30
.3
YEAR
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
(2.4)
(5.2)
(47)
(102)
(136)
(112)
(116)
(152)
(232)
(157)

FIGURE C-5

exports. In 1979, lumber exports reached a 10-year high, but still were only 6 percent of total exports from Grays Harbor. A similar picture holds for other areas. Census data shows that in 1979 lumber exports, as a percent of total major commodity exports, were 0.8 percent for the United States, 2.4 percent for the Pacific coast, 3.2 percent for the Pacific Northwest, and 2.4 percent for the State of Washington. Lumber exports are far less concentrated in the Pacific Northwest than are log exports. In 1979, 93 percent of all United States log exports were shipped from Pacific Northwest ports. By comparison, the Pacific Northwest accounted for a much lower 51 percent of total United States lumber exports, the balance being shipped from Oregon and California ports. Grays Harbor accounted for 5 percent of all United States lumber exports in 1979.

(1) Market Analysis - Lumber. The market forces determining future lumber exports are similar to those that determine future log exports. Demand for housing is the primary driving force of Japanese demand for softwood logs and finished lumber. Specifically, Japanese timber demand is a function of new household formation and new housing starts, both of which are forecasted to decline as the Japanese population matures. In the United States, the continuing shift of the timber industry to the southeast United States has progressively pushed the domestic market for Pacific Northwest lumber west of the Rocky Mountains. Therefore, additional timber supplies will be available for Pacific Rim trade. In addition, west coast shares of the United States northeast lumber market have declined from 30 percent in 1964 to less than 5 percent in 1978 because Canadian mills can ship lumber to the United States east coast cheaper (i.e., $20/mbf less) than Pacific Northwest mills. Canada can use less costly foreign flag vessels, whereas the United States producers are required by the Jones Act to use United States ships. Accordingly, an increasing share of export lumber from the Pacific coast will be available for Pacific Rim trade, allowing for a continuation of historic shares of export cargo. Pacific Northwest exports as a percent of Pacific coast is expected to remain relatively constant.

(2) Project Lumber Exports. The same four independent studies that project log exports from Washington or Grays Harbor also projected lumber exports. The underlying assumptions and forecasting methodologies of the forecasts were evaluated, as was done with log exports. The most recent forecasts were from the 1980 Port System Study and the 1981 Forest Policy Project. According to the 1980 Port study, the key to future increased levels of United States lumber exports to Japan is based on the transition of traditional Japanese residential construction methods to acceptance of western-style housing using standard United States lumber sizes. Industry officials maintain that the acceptance of western-style housing would provide expanded opportunities to sell more United States finished lumber to Japan. Continued prospects for increasted levels of platform frame houses appear optimistic, according to the Port study. The study's overall outlook was that lumber exports would continue increasing at or slightly higher than present

ALTERNATIVE LUMBER EXPORT FORECASTS
GRAYS HARBOR

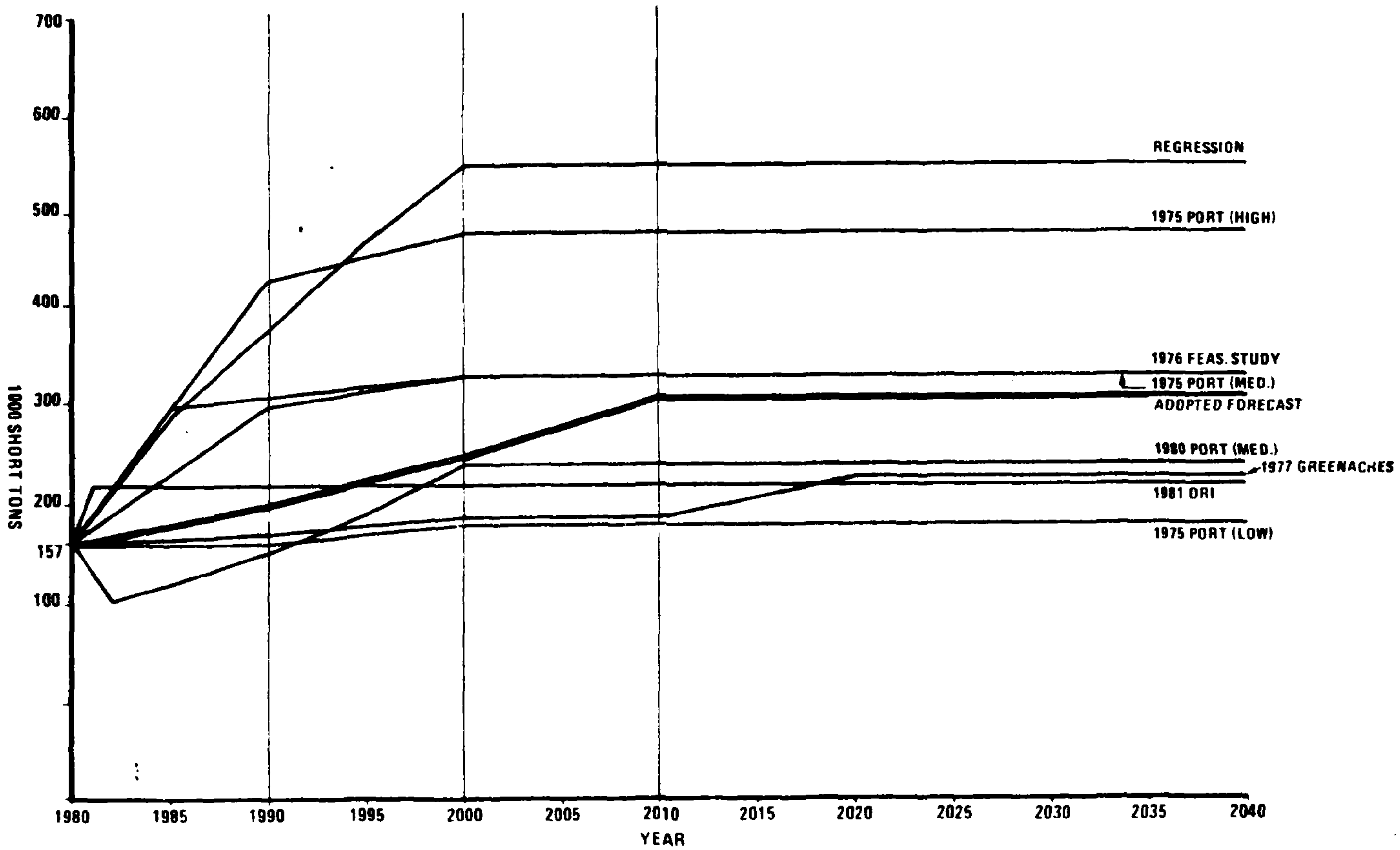


FIGURE C-6

growth rates, depending on trade agreements between the United States and Japan. The Port study also included demand for lumber in many other Pacific Rim countries plus Atlantic Europe and Mediterranean countries. The DRI forecast in the Forest Policy Project projected that Japanese preference for wooden dwellings would remain strong in the face of exhorbitant land prices, mainly due to traditional preference for wooden homes. The DRI analysis did not rule out the eventual transition of traditional Japanese construction to western-style housing using standard United States lumber sizes. However, the lumber export forecast reflected DRI's skepticism of the ability of the 2 x 4 home to penetrate the Japanese market, since the 2 x 4 homes are so much more expensive than traditional homes. The DRI forecast assumed United States lumber exports to Japan would not increase much beyond their 1979 level of 4.0 million cubic meters, which DRI considered to be a high level.

(3) Adopted Lumber Export Forecast. The four independent lumber export forecasts plus the regression and 1976 feasibiltiy study forecasts are displayed in figure C-6. The adopted lumber export forecast was between the DRI forecast and the 1980 Port study forecast. Based on historical volumes, the Port Study forecast appeared too low in the early years of the forecast period, as shown in figure C-6. The low forecast may be due to the census data used as a base for the forecast. For example, the 1979 census volume of 158,000 tons which was used as the basis for the forecast was considerably lower than the actual volume shown in Port of Grays Harbor Records of 232,000 tons. On the other hand, the DRI forecast, as derived as 222,000 short tons per year, appears too high in the early years based on historical volumes. Further into the forecast period, the Port study is low because it did not allow for a change in export mix of lumber for logs, and the DRI forecast is low because it did not include demand by countries other than Japan. Accordingly, the adopted forecast was based on actual 1980 volumes, rising by 1990 to a volume between DRI and the Port forecast, and reaching a peak by the year 2010 in excess of both forecasts. The adopted forecast is shown in table C-8 and in figure C-6.

TABLE C-8

ADOPTED LUMBER EXPORT FORECAST
(Thousands of Short Tons)

Year	Volume
1980	157
1990	200
2000	250
2010	310
2040	310

Average Annual Equivalent: 1990-2010 : 240
2010-2040 : 310
1990-2040 : 256

Over the 1990-2040 forecast period, the adopted lumber export forecast expressed as an average annual equivalent (at 7-5/8 percent interest) equals 256,000 short tons per year. Similarly, the adopted log export forecast expressed as an average annual equivalent is 2,300,000 short tons per year (see table C-1). The total volume of log and lumber exports is thus forecasted to average 2,556,000 short tons per year from 1990 to 2040. Over the 1970-1980 period, combined log and lumber exports from Grays Harbor averaged 2,638,000 short tons per year. Accordingly, the adopted forecasts reflect industry opinion that total log and lumber export volume in the future will probably not be significantly different from the current combined volume, and also that there will be a change in export mix in favor of more lumber and fewer logs.

c. Woodchips. The total volume of woodchips shipped from Grays Harbor during the period 1968 through 1980 is shown graphically in figure C-7. The historical data show that chip exports have declined steadily since reaching a peak in 1970. The only chip loading facility in the harbor is the Weyerhaeuser facility upstream of the Chehalis River bridge. There is a possibility that a second facility could be built near the mouth of the Hoquiam River by a consortium of timber companies in Grays Harbor, but the potential volume of chips from this facility were not included in project evaluation. Woodchips, a by-product when trees are milled into lumber, are used to make pulp which is used to make paper. The forecasted increase in lumber exports indicates that the supply of chips will grow considerably over the future. The remaining variable is the overseas demand for chips, which thus far has been limited exclusively to Japan.

(1) Projected Woodchip Exports. The 1980 Port study and the 1981 Forest Policy Project both projected growth in export demand for woodchips. The Port study forecasted an increase in Japanese demand for paper and paper products of 2.5 to 3.0 percent annually between 1980 and 1990. There are presently six woodchip exporting terminals in Washington State: two in Tacoma, three in Longview, and one in Grays Harbor. The Port study projected woodchip exports from Washington would more than quadruple by the year 2000 and that two new chip facilities would be required, both in the Lower Columbia region. The DRI forecast contained in the Forest Policy Project also projected growth in paper production, both in the Pacific Rim countries, which would be supplied by west coast exporters and in Scandanavian countries, which would be supplied by southeastern United States exporters. DRI also projected a strong domestic demand for chips, particularly on the west coast. Therefore, DRI projected only a modest increase in west coast chip exports of about 0.56 percent per year from 1979 to 2020. This growth rate was applied to Grays Harbor to derive a Grays Harbor forecast. The Weyerhaeuser forecast was that chip exports from their Grays Harbor facility would remain constant from 1980 to 2000. The company did not make a projection beyond the year 2000. These alternative forecasts of woodchip exports, plus a regression forecast and a 1976 feasibility report forecast for comparison, are shown in figure C-8.

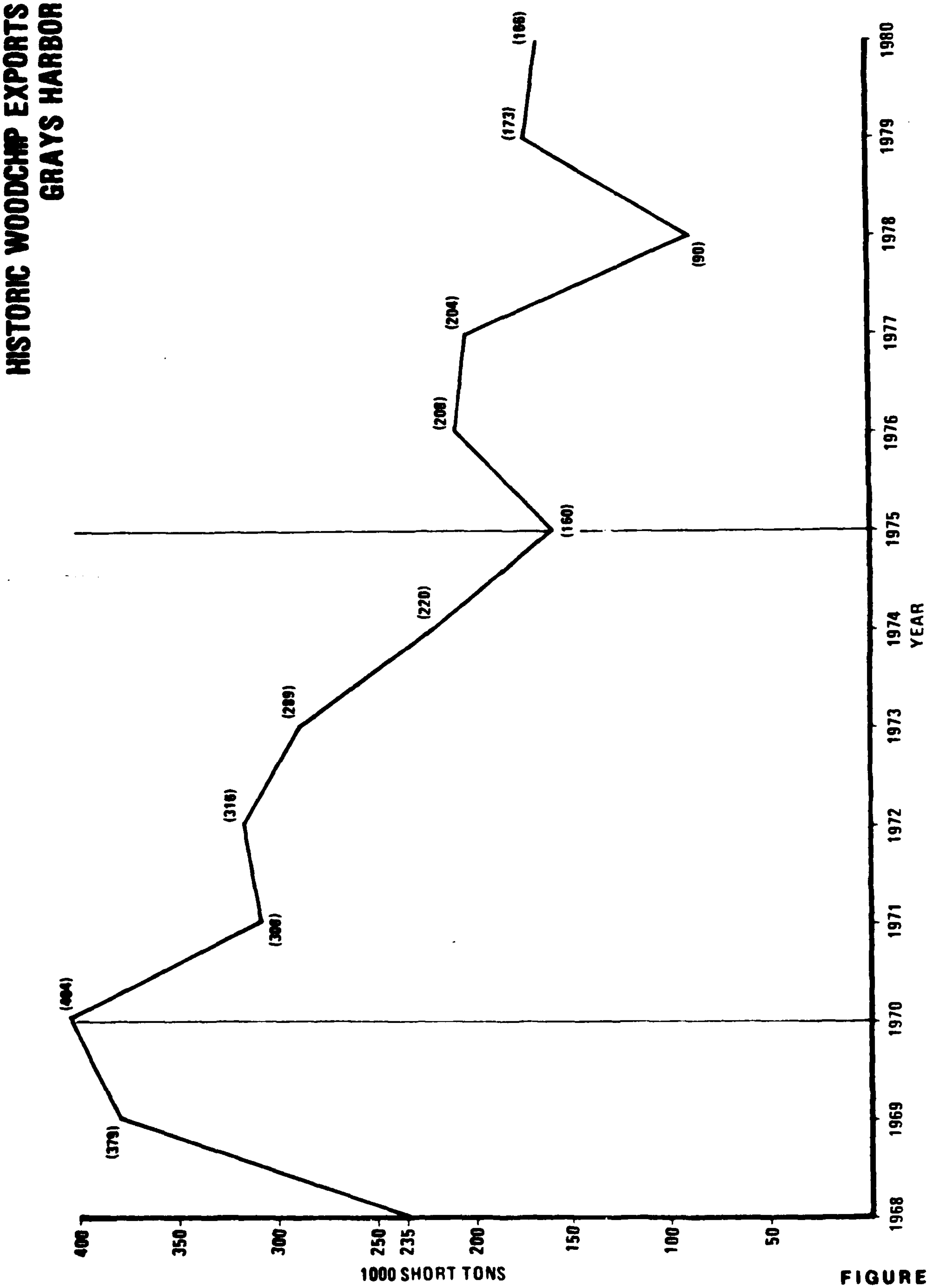

HISTORIC WOODCHIP EXPORTS
GRAYS HARBOR
(379)
(404)
(308)
(318)
(289)
(220)
(160)
(208)
(204)
(90)
(173)
(166)
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
YEAR
400
350
300
250
235
200
150
100
50
1000 SHORT TONS

FIGURE C-7

(2) Adopted Woodchip Export Forecast. The adopted forecast, shown in table C-9 and figure C-8, was based on the DRI and Port study forecasts to the extent there would be long-term growth in the chip export market, and also on the Weyerhaeuser forecast to the extent that export volumes would remain constant to the year 2000. Because of horizontal clearance restrictions imposed on Grays Harbor woodchip vessels by the Union Pacific Railroad (UPRR) Bridge over the Chehalis River at Aberdeen, woodchip vessel over size will permanently be limited to about 24,000 DWT if the bridge is not widened. Even with widening of the UPRR Bridge however, vessel size would increase only to 35,000 DWT because of limitations on vessel length imposed by the channel configuration above the bridge. The volume of woodchips exported will not change dramatically in absolute terms because there are no transportation economies to support such a change. This assumes, of course, that a second woodchip facility is not constructed below the bridge. Accordingly, future changes in export volumes were not seen as being of a large magnitude.

TABLE C-9

ADOPTED WOODCHIP EXPORT FORECAST
(Thousands of Short Tons)

Year	Volume
1980	166
1990	166
2000	166
2010	200
2040	200

Average Annual Equivalents: 1990-2010 : 171
2010-2040 : 200
1990-2040 : 177

2.04 Vessel Fleet Composition. Forest products carriers are ships specifically designed to carry one or more forest products in bulk and consist of timber carriers (i.e., log and lumber ships), woodchip carriers, and pulp carriers. A detailed analysis of the existing and future vessel fleets is presented in exhibit 2. The following information has been extracted from the exhibit and is presented in summary form.

a. Log Vessels. A profile of the timber carrier fleet presently calling at Grays Harbor was determined from monthly reports on shipping activity compiled by: (1) the Port of Grays Harbor, (2) longshoring companies in Grays Harbor, and (3) the Grays Harbor pilots. The reports covered the 10 months of January through October 1980 and were the most up-to-date records available at the time the fleet analysis was prepared. This 10-month sample provided accurate baseline data for existing vessel

ALTERNATIVE WOODCHIP EXPORT FORECASTS
GRAYS HARBOR

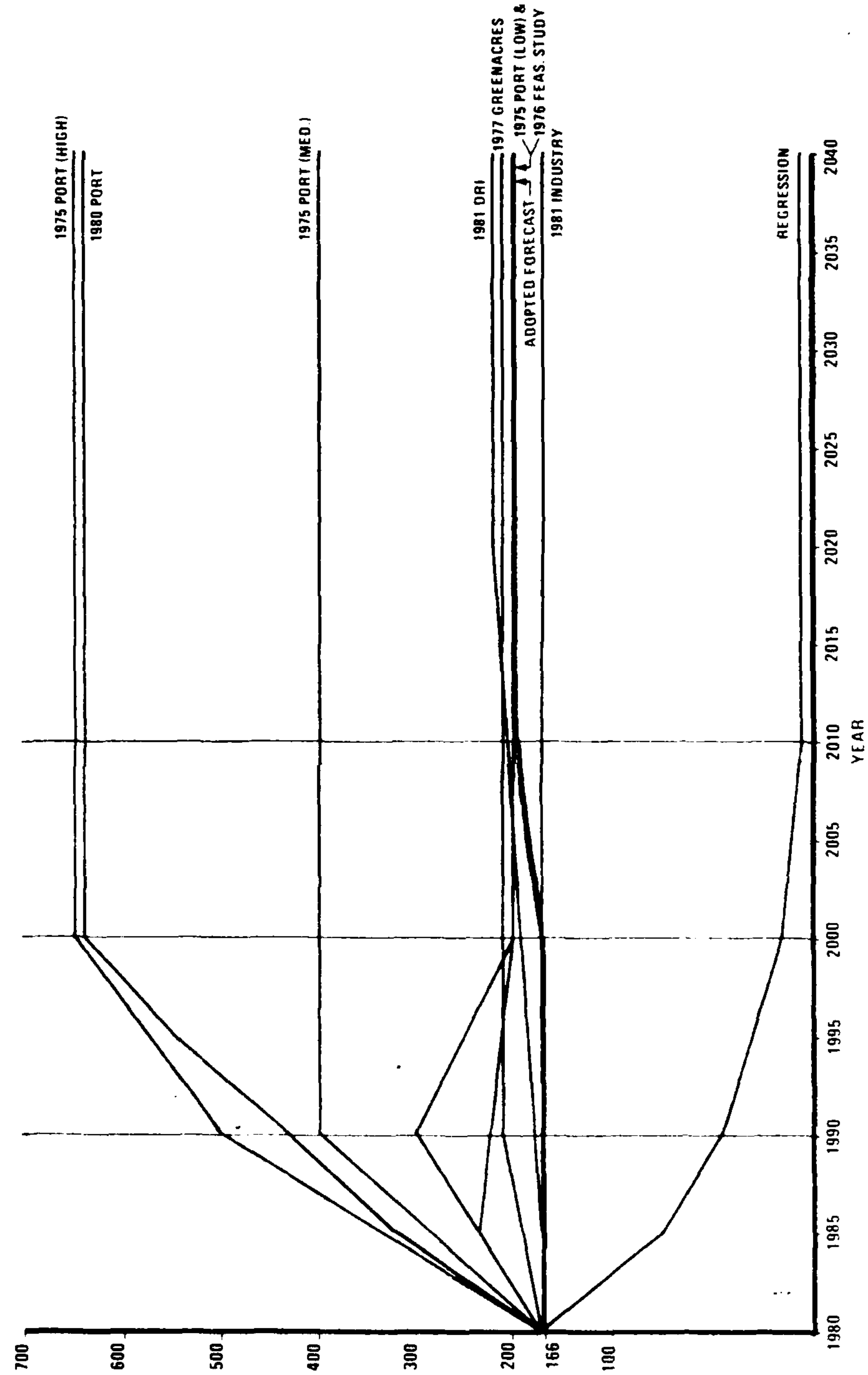


FIGURE C-8

TABLE C-10

LOG VESSELS CALLING AT GRAYS HARBOR IN 1980

Deadweight (long tons)	No. of Ships	Percentage of Total	No. in Sample	Avg. DWT (tons)	Avg. NRT (tons)	Avg. Length (feet)	Avg. Beam (feet)	Avg. Design Draft (feet)	Avg. Sail Draft (feet)	Avg. Age (years)
10,000-14,999	2	1	2	12,295	4,765	397.7	63	29.7	29.0	9.0
15,000-19,999	60	38	32	18,068	7,115	494.0	75.1	30.6	31.2	8.0
20,000-24,999	63	39	21	23,055	9,347	541.9	79.9	31.8	32.2	5.6
25,000-29,999	30	19	17	26,833	10,467	563.1	83.0	33.6	33.1	5.2
30,000-34,999	5	3	5	32,742	12,635	588.4	91.4	36.1	29.8	4.7
35,000-39,999	0	0	--	--	--	--	--	--	--	--
TOTAL	160	100	77							
FLEET AVERAGE				22,061	8,764	527.7	78.8	31.8	31.9	5.7

Source: Port of Grays Harbor Monthly Shipping Reports, 1980. Average age is number of years between 1980 and year of vessel construction.

movements in Grays Harbor under the without-project condition, as shown in table C-10. In addition, an historical trend was analyzed by looking at average log vessel size in 1980 compared with average log vessel size in 1973 (when the previous detailed fleet analysis was conducted), as shown in table C-11.

TABLE C-11

COMPARISON OF LOG VESSEL FLEETS
GRAYS HARBOR, 1973 AND 1980

Characteristic	Fleet Average In 1973	Fleet Average In 1980	Change	Percent Change
Size	17,893.00 DWT	22,061.0 DWT	4,168.00 DWT	23
Length	495.75 feet	527.7 feet	31.95 feet	6
Beam	73.34 feet	78.8 feet	5.46 feet	7
Design Draft	30.6 feet	31.8 feet	1.2 feet	4
Sail Draft	29.5 feet	31.9 feet	2.4 feet	8

Source: Port of Grays Harbor Monthly Shipping Reports, 1973 and 1980.

Over the 7 years, from 1973 to 1980, average log vessel size in Grays Harbor increased 23 percent. This is an increase of 4,168 DWT per year. Table C-11 also shows increases in vessel length, beam, and draft. Although all vessel dimensions have not increased at the same rate over the past 7 years, this historical analysis clearly demonstrates that the trend in log vessels calling at Grays Harbor has been to larger, longer, wider, and deeper draft vessels. However, without deepening of the channel vessel size is not expected to increase appreciably in the future.

b. Lumber Vessels. Lumber and log vessels both belong to the fleet of forest products carriers commonly designated as timber carriers. However, the distinction between log and lumber vessels is ambiguous because lumber vessels on occasion also carry logs or pulp with their lumber cargo, and log vessels sometimes carry combined cargoes of logs and lumber. This is not a frequent occurrence, maybe 3 or 4 times a year in Grays Harbor, but it does indicate the vessels are not permanently and exclusively committed to one cargo. Lumber vessels are analyzed separately here, but in the projections of future vessel fleet and in the benefit calculations, lumber and log vessels were treated as homogeneous and under the general category of timber carriers. From January through October 1980, 13 lumber vessels called at Grays Harbor.

These vessels ranged in size from the 16,600-DWT USA Maru to the 44,000-DWT Hoegh Minerva and Hoegh Miranda. The "Hoegh class," or "M class," vessels are the largest timber carriers calling at Grays Harbor. These vessels make several ports of call before sailing for Japan. On one occasion, for example, the Hoegh Miranda made stops at Longview and Grays Harbor, Washington, and then at Vancouver and Nanaimo, British Columbia. Only one of the 13 lumber vessels arrived empty and sailed fully loaded. The remaining 12 were either partially loaded inbound, outbound, or both. Table C-12 summarizes pertinent characteristics of the lumber vessels. The average fleet size of 29,793 DWT is much larger than the 22,061 DWT for log vessels, due in part to the influence of the Hoegh class vessels on the fleet average, which never left fully loaded. Multiple ports of call (i.e., three or four stops) are characteristic of the existing lumber vessel fleet, especially the Hoegh class vessels. Buyers in Japan may buy a certain quantity, dimension, and species of lumber from one port and another quantity, dimension, and species or a completely different product at an alternate port. Vessels carrying the lumber or mix of forest products thus have to make several stops to pick up all the cargo. When the vessels arrive in Japan, they may also make several stops, unloading their cargo in the reverse order in which it was loaded. The port rotation pattern on the west coast is dictated by the port rotation pattern in Japan. The cargo picked up at Grays Harbor must be among the last unloaded in Japan because with its present channel dimensions, Grays Harbor can accommodate these vessels only on their first or second port of call, when their drafts are below maximum. Consequently, Grays Harbor is frequently bypassed by larger vessels seeking a third or fourth port of call because the -30-foot channel limits the draft and flexibility of the vessels. According to the Grays Harbor pilots, a deeper channel at Grays Harbor would reduce the frequency of partial loading and the number of ports of call, and many of the vessels now leaving Grays Harbor partially loaded would leave fully loaded.

c. Pulp Vessels. A total of 12,269 short tons of pulp were exported from Grays Harbor in 1980 on five ships. Two of the shipments were combined with lumber on a lumber vessel. One of the shipments was loaded on a vessel that on a previous call at Grays Harbor carried a full load of logs. Another pulp shipment was put on a vessel that previously carried a partial load of lumber out of Grays Harbor. That is, four of the five pulp shipments were put on timber carriers rather than vessels specifially designated as pulp carriers. Accordingly, the fleet analysis for log and lumber vessels was assumed to be appropriate for pulp vessels as well, and a separate fleet analysis for pulp carriers was not considered necessary.

d. Woodchip Vessels. The woodchip carrier fleet was created to supply Japan's paper and board industry with pulpwood shipped in the form of woodchips. Nearly all the woodchip carriers operating in the Pacific are Japanese-flag, and were built in response to long-term freight contracts or cargo guarantees. Bulk woodchip carriers are unique from conventional bulk carriers because of the cargo density.

TABLE C-12

LUMBER VESSELS CALLING AT GRAYS HARBOR IN 1980

Deadweight (long tons)	Number of Ships	Percentage of Total	Avg. DWT (l. tons)	Avg. NRT (l. tons)	Avg. Cargo Load (s. tons)	Avg. Length (feet)	Avg. Beam (feet)	Avg. Design Draft (feet)	Avg. Sail Draft (feet)	Avg. Age (years)
10,000-14,999	0	0	-	-	-	-	-	-	-	-
15,000-19,999	3	23	17,627	6,750	9,524	492.3	72.7	30.1	28.07	5
20,000-24,999	0	0	-	-	-	-	-	-	-	-
25,000-29,999	5	38	26,038	10,254	9,185	569.9	82.7	32.7	27.00	5.8
30,000-34,999	1	8	30,295	12,307	6,539	645.1	75.1	35.6	31.05	11
35,000-39,999	0	0	-	-	-	-	-	-	-	-
40,000 or more	4	31	43,292	16,793	10,802	657.7	101.2	37.9	31.04	4
TOTAL	13	100								
FLEET AVERAGE			29,793	11,639	9,552	585.3	85.5	33.9	29.00	5.5

SOURCE: Port of Grays Harbor Monthly Shipping Reports, 1980. Average age is number of years between 1981 and year of vessel construction.

TABLE C-13

WOODCHIP CARRIERS CALLING AT GRAYS HARBOR IN 1980

Deadweight Tons (long tons)	Number of Ships	Average DWT (l. tons)	Average NRT (tons)	Average Length (feet)	Average Beam (feet)	Average Age (years)	Average Sail Draft (feet)	Average Design Draft (feet)
10,000-19,999	0							
20,000-29,999	12	23,627	14,013	553.98	79.37	10.3	28.95	31.77
30,000-39,999	0							
40,000-49,999	0							
50,000-59,999	0							
Total	12							

Source: Port of Grays Harbor Monthly Shipping Reports, 1980.

Woodchips stow at one-half to one-third the density of other bulk commodities such as grain and phosphate rock. Woodchip carriers are therefore considerably deeper and slightly wider beamed than conventional bulk carriers. Even at that, a typical chip ship does not have sufficient cubic capacity to stow more than about 70 percent of its deadweight capacity. Conventional bulk carriers hauling chips would carry an even smaller percentage of their deadweight capacity. Twelve woodchip carriers (23,627 DWT average) called at Grays Harbor in 1980 and departed with a total of 183,123 short tons of woodchips, averaging 15,960 short tons per carrier or 58 percent of short ton deadweight capacity (i.e., 15,260/23,627 x 1.12). The variation in vessel size was very small, ranging from 22,110 DWT to 24,813 DWT and averaging 23,627 DWT, as shown in table C-13. Several vessels made two or more repeat calls at Grays Harbor during the year, and four vessels made a second port of call after leaving Grays Harbor. The vessels that called at Grays Harbor in 1980 were much smaller in terms of DWT, NRT (net registered tons), length, beam, and draft than the average size vessel in the world fleet (e.g., 23,627 DWT vs. 34,300 DWT; see exhibit 2, tables 12 and 13). Woodchip carriers calling at Grays Harbor are comparatively small because their width or beam is restricted by the 125-foot horizontal clearance of the Union Pacific Railroad bridge on the Chehalis River at Aberdeen. Chip carriers must pass through this bridge opening to reach the chip loading facility upstream of the bridge. Therefore, woodchip vessel beams seldom exceed 82 feet, and this typically limits vessel size to less than 30,000 DWT. The limitations on vessel beam and size imposed by the railroad bridge were also evident in 1973, when 17 of the 18 vessels were under 30,000 DWT. The average vessel size in 1973 was 23,880 DWT, almost the same as in 1980. Other vessel characteristics between the 1973 and 1980 woodchip fleets in Grays Harbor are compared in table C-14. While the world woodchip carrier fleet has shown a trend toward larger, deeper draft vessels, the fleet calling at Grays Harbor has historically remained relatively undersized and unchanged. The average size (i.e., DWT, length, beam, and draft) of woodchip vessels calling at Grays Harbor will not increase very dramatically in the future as long as the railroad bridge restricts vessel beams to about 82 feet. More than 60 percent of the woodchip carriers in the world fleet cannot call at Grays Harbor because they cannot fit through the bridge opening. On the other hand, potential economies of scale savings would accrue to shippers if the bridge were widened to allow the larger, more cost effective vessels of the world fleet to call at the chip loading facility.

TABLE C-14

COMPARISON OF WOODCHIP VESSEL FLEETS
GRAYS HARBOR, 1973 and 1980

Characteristic	Fleet Average in 1973	Fleet Average in 1980	Change	Percent Change
Size	23,880.0 DWT	23,627.0 DWT	-253 DWT	-1.06
Length	574.56 feet	593.98 feet	19.42 feet	3.38
Beam	80.95 feet	79.37 feet	-1.58 feet	-1.95
Design Draft	27.99 feet	31.77 feet	3.78 feet	13.50
Sail Draft	31.88 feet	28.95 feet	-2.93 feet	-9.19

e. Future Timber Carrier Fleet. Several studies have been conducted over the past 6 years on characteristics and future trends in world fleet timber carriers. These studies are the 1975 Port System Study; the Merchant Fleet Forecast of Vessels in U.S.-Foreign Trade, 1980-2000, prepared for the Maritime Administration by the Massachusetts consulting firm of Temple, Barker, and Sloane (TBS) in May 1978; and third, a seven-volume effort called Development of a Standardized U.S. Flag Dry-Bulk Carrier. This study was also prepared for MarAd by the New York consulting firm of M. Rosenblatt and Son Inc. (RSI), in January 1979. The various studies focused either on regional or national trends in timber carrier size and, therefore, provided a good cross section of expert opinion on the future world fleet. These studies were reviewed and analyzed (see exhibit 2 for details) and used as a basis for forecasting trends in vessel characteristics of the future timber carrier fleet calling at Grays Harbor. The Port System and TBS forecasts were more explicit in their forecasts of future timber carrier size than was the RSI forecast. The TBS forecast said average vessel size would be 21,705 DWT in 1980 and 26,514 DWT in the year 2000. The Port System Study forecast said average timber carrier size would increase from 22,000 DWT in 1980 to 35,000 DWT in the year 2000. The RSI study did not forecast average vessel sizes but, rather, designated very broad vessel size groups (i.e., 20-34,999 DWT and 35-49,999 LWT) and allocated a share of total forest products commerce to each group. Each vessel size group in the RSI study spanned a range of 15,000 to 20,000 DWT, which was too broad to meaningfully determine a representative average size vessel. All three studies forecasted an increase in the average size of timber carriers in the world fleet between 1980 and the year 2000, with the majority of vessel sizes and cargo carried focusing in the 20,000-35,000 DWT range. This is the size range frequently referred to as "handy-sized bulk carriers." The remainder of the forest products cargo will be carried on vessels larger than 35,000 DWT.

Historical data on the composition of the timber carrier fleet calling at Grays Harbor showed the average size of timber carriers had increased from 17,893 DWT in 1973 to 22,061 DWT in 1980, an increase of 23 percent (see table C-11). Three studies that looked at future trends in world fleet timber carrier size were reviewed, and all three indicated the historical growth in average vessel size that had occurred in Grays Harbor could be expected to continue in the world fleet over the next 20 years. Whether or not similar growth in average vessel size will occur in Grays Harbor depends on channel improvements. The projected timber carrier fleet expected to be calling at Grays Harbor, under the with-project condition, is shown in table C-15. The vessels range in size from 15,000 to 45,000 DWT. Only two log vessels smaller than 15,000 DWT called at Grays Harbor in 1980, compared with 25 in 1973, so 15,000 DWT appeared to be a reasonable lower limit. At the other end of the spectrum, the upper limit on future timber carrier size was assumed to be 45,000 DWT, since the 44,000-DWT Hoegh class vessels now calling at Grays Harbor are the largest timber carriers in the world fleet. The largest vessel that can call above the bridge is 30,000 DWT, even with

UPPR bridge replacement. According to the Grays Harbor pilots, the configuration of the channel above the bridge and the need for navigation safety will limit vessel length to approximately 600 feet.

Without channel improvements, the average size of the future timber carrier fleet was forecast to reach a limit of 22,500 DWT. The major limiting factor in continued vessel growth at Grays Harbor is the existing authorized channel depth of -30 feet. Vessels routinely depart Grays Harbor with drafts in excess of the -30-foot channel depth for several reasons: (a) the vessels rely on tides to provide needed underkeel clearance; (b) underkeel clearance is frequently less than the 5 feet used in Corps design criteria; and (c) actual channel depth is frequently deeper than authorized depth due to the practice of advance maintenance dredging. Nevertheless, there is a physical limit as to how far vessel draft can increase without channel impprovements. In forecasting the average size of the future timber carrier fleet to maximize at 22,500 DWT without the project, the future fleet's average draft would correspondingly be forecasted to maximize at approximately 32 feet, maybe a little more. That is, some timber vessels would depart Grays

TABLE C-15

PROJECTED TIMBER CARRIER FLEET WITH THE PROJECT
GRAYS HARBOR

Vessel Size (DWT)	Cargo Load (short tons)1/	Design Draft (feet)	Sail Draft (feet)	Beam (feet)	Length (feet)
15,000	13,400	29	29	70	490
20,000	17,900	31	31	77	530
25,000	22,400	33	33	82	560
30,000 2/	26,900	34	34	88	590
35,000	31,400	35	35	92	620
37,000	33,200	35	35	95	630
40,000	35,800	36	36	97	640
45,000	40,300	37	37	102	658

1/Figured on 80 percent of short-ton deadweight capacity (i.e., DWT x 1.12 x .80) and rounded to nearest 100 tons. See exhibit 2.

2/Beam on this size vessel requires UPRR Bridge widening. This is also the largest vessel, on average, that can call above the bridge because of the 600-foot length limitation.

NOTE: Numbers in table are rounded averages of world fleet and Grays Harbor vessel characteristics. Actual dimensions for a specific vessel may be slightly larger or smaller than those shown in the table due to the use of averages.

Harbor with drafts less than 32 feet and some with drafts greater than 32 feet, but the average of all vessels would be approximately 32 feet. The maximum tide that fully-loaded vessels can routinely rely on and utilize to sail from Grays Harbor is about 4 feet (see discusson of figure 9 in paragraph 2.07). Assuming a -30-foot channel, a 4-foot tide would give a 32-foot draft vessel a maximum underkeel clearance of only 2 feet (i.e., 30-foot channel + 4-foot tide 32-foot draft = 2-foot clearance). If the existing channel is instead assumed to be -32 feet deep rather than -30 feet, the tide would give the same 32-foot draft vessel an underkeel clearance of 4-feet, which is a reasonably safe clearance. However, vessels with drafts greater than 32 feet would then have less than 4 feet clearance and run the risk of bumping bottom and vessel damage. The point is that the existing channel in Grays Harbor, whether it is assumed to be -30, -31, or -32 feet deep, is not deep enough to accommodate a future fleet whose average size is significantly larger than the average size of the 1980 fleet. For this reason, future growth in the average size of the without-project fleet was limited to 22,500 DWT. This limit applies to the 1990 to 2040 study period.

f. Future Woodchip Carrier Fleet. Woodchip vessels in the 1980 world fleet ranged in size from 14,800 DWT to 57,000 DWT, with a fleet average of 34,300 DWT (see exhibit 2, table 12). The trend in vessel construction appears to be toward larger vessels. Three examples of this are: (1) the majority of the 38 chip carriers on order in 1974 were in the 40,000- to 45,000-DWT range; (2) three vessels built in 1977 averaged 40,000-DWT; and (3) chip carriers under construction in 1980 included the 45,000-DWT Empress of Eden and an unnamed 43,000-DWT vessel scheduled for delivery in 1981. Since these vessels are intended for trade with Japan, their size is not constrained by the Panama Canal limitations (e.g., maximum beam of 105.6 feet). The 40-foot draft limitation of the Panama Canal and of many ports in the world similarly does not pose as serious a limitation on woodchip vessels as on conventional bulk carriers. Due to the light density of the cargo and relatively wider beams, woodchip vessels operate at about 80 to 90 percent of their full load draft when at full cubic capacity with chips. The largest woodchip vessels now being built, up to and including 57,000 DWT, have design drafts of only about 38 feet.

The 1975 Port System Study provided the only detailed analysis of the future woodchip carrier fleet. In forecasting the vessel sizes, the Port study assumed that if the woodchip trade was not projected to grow over time, there would be little incentive to expand the terminal facilities to accommodate much larger ships or much larger accumulations of cargo. The study projected the woodchip trade in Grays Harbor would remain constant over the forecast period and, therefore, forecasted that the average size ship calling at Grays Harbor in the future would not be much larger than the present average. The study did not mention the horizontal clearance restriction of the railroad bridge at Aberdeen as a factor in limiting woodchip vessel size. While the study may have a point in assuming terminal facilities would not expand if trade were not

also expected to expand, a similar argument is not as persuasive in forecasting vessel sizes. As rapidly rising world oil prices translate into higher diesel fuel prices, costs of deep-draft shipping will continue to escalate. Forest products are relatively low-valued commodities, as compared with autos or similar manufactured products, and are bulk in nature. Transportation costs are a significant factor in the final price of relatively low-valued commodities, and the commodities can absorb only small transportation cost increases without affecting demand. If the demand for a commmodity is price elastic and transportation costs represent a significant percentage of the total cost, shippers will be extremely sensitive to transporation costs and policies. (Japanese demand for Northwest woodchips is highly price elastic because Japan also imports significant tonnages from Australia, New Zealand, Malaysia, the Phillippines, and the U.S.S.R. This means there are readily available substitutes for Northwest chips.) Forest products companies in Grays Harbor rely heavily on foreign export markets and have strong economic incentives to keep waterborne transportation costs as low as possible at all times. This means using the largest, most cost efficient vessels available, even if the future growth curve for a particular commodity may be flat or declining. Therefore, the Port study conclusion that Pacific coast subregion woodchip carriers will increase in size very little by the year 2000 is valid as long as the railroad bridge restricts growth of average vessel size. If the bridge restrictions were removed, larger vessels which dominate the world fleet would more than likely start calling at the woodchip facility up to the maximum 600-foot length limitation. The projected woodchip carrier fleet, or the fleet expected to be calling at Grays Harbor, assuming bridge widening and channel deepening, is shown in table C-16. The forecast

TABLE C-16

PROJECTED WOODCHIP CARRIER FLEET WITH THE PROJECT
GRAYS HARBOR

Vessel Size (DWT)	Cargo Load (short tons)1/	Design Draft (feet)	Sail Draft (feet)2/	Beam (feet)	Length (feet)
22,000	15,500	31	27	79	555
24,000	16,900	31	28	81	570
26,000	18,300	32	29	83	575
28,000	19,800	33	30	85	590
30,0003/	21,200	33	30	88	600

1/Sixty-three percent of short-ton deadweight capacity (i.e., DWT x 1.12 x .63) and rounded to nearest 100 tons.

2/Figured on design draft times 90 percent and rounded to nearest whole foot.

3/Beam on this size vessel requires UPRR bridge widening. This is also the maximum size vessel, on average, that can call above the bridge because of the 600-foot length limitation.

NOTE: Numbers in table are rounded averages of vessel world fleet and Grays Harbor woodchip vessel characteristics. Actual dimensions for a specific vessel may be slightly larger or smaller than those shown in the table due to the use of averages.

also assumes a second chip facility is not constructed below the bridge, in which case vessel size could range up to the maximum 57,000 DWT. Under the without-project condition, woodchip vessel size would maximize at approximately 24,000 DWT because of beam restrictions imposed by the UPRR bridge.

2.05 Vessel Operating Costs. Vessel operating costs per ton of cargo were determined for the projected timber carrier and woodchip carrier fleets using cost data for foreign flag dry-bulk vessels provided by the Office of the Chief of Engineers (OCE). Costs were updated to October 1981 prices, and calculated for the cost in port to load the cargo and the cost at sea to make the 8,500 nautical mile round trip between Grays Harbor and Japan. The details of deriving these costs are shown in exhibit 2. Operating costs per ton of cargo for the vessels are shown in table C-17.

TABLE C-17

VESSEL OPERATING COSTS PER TON OF CARGO
(October 1981 Prices)

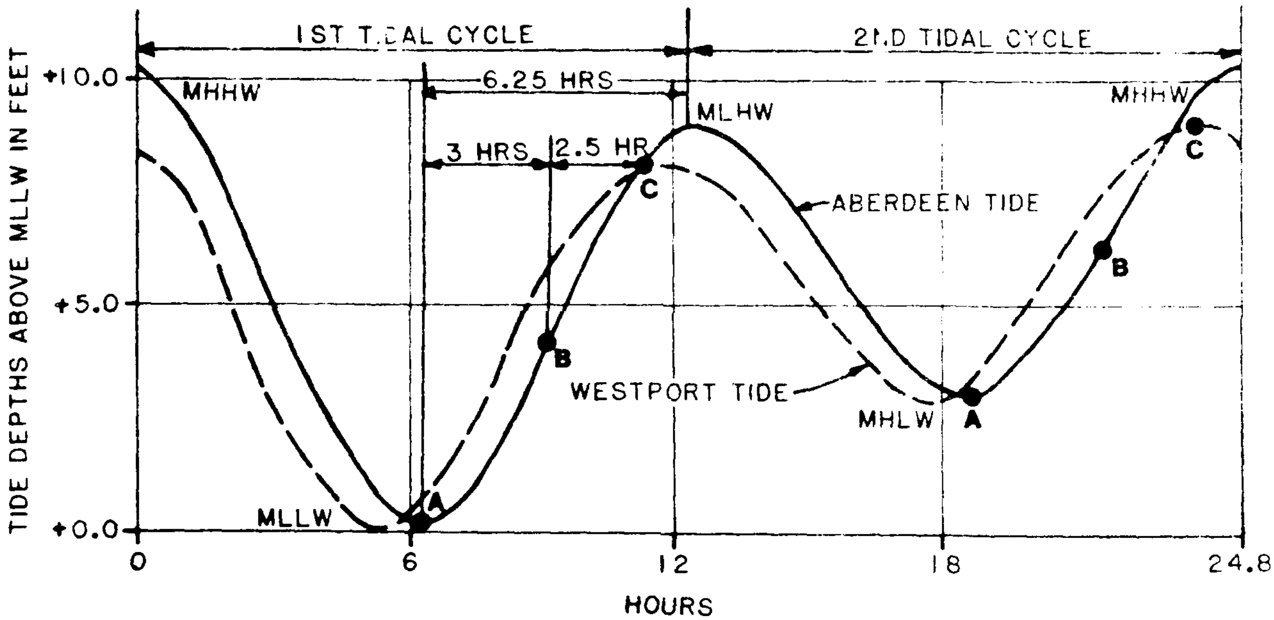
Timber Carriers		Woodchip Carriers	
Vessel Size (DWT)	Cost Per Ton	Vessel Size (DWT)	Cost Per Ton
15,000	$32.29	22,000	$22.50
20,000	29.59	24,000	21.20
25,000	23.22	26,000	20.17
30,000	21.59	28,000	19.27
35,000	20.05	30,000	18.16
37,000	19.25		
40,000	18.53		
45,000	17.69		

2.06 Current and Future Cost of Commodity Movements. The cost per ton of shipping forest products from Grays Harbor was calculated using a fleet approach, with the fleet expressed as an average vessel size. For example, at the presently authorized channel depth of -30 feet, the average average size of the entire log vessel fleet that called at Grays Harbor in 1980 can be represented as a single average vessel size of 22,061 DWT as shown in table C-11. This average vessel size (rounded to 22,000 DWT), was assumed to represent the future without-project base condition as of the year 1990, project year one. Beyond 1990, a slightly larger average vessel size would result because vessel sizes are expected to increase over time. For the years 2010 to 2040, average vessel size was assumed to be 22,500 DWT, as discussed in paragraph 2.04(e). In a similar fashion, two average vessel sizes were assumed for each foot of channel depth from -31 feet to -45 feet, one size starting in 1990 and increasing 500 DWT up to the second size in 2010,

and then held constant to the year 2040. The average vessel sizes designated for each channel depth were determined by taking the vessels' fully loaded sailing drafts; adding requird clearances for trim, squat, freshwater sinkage, and wave action (where necessary); and deriving how deep the channel would have to be in order to accommodate the draft being analyzed. Underkeel clearance provided by tides was also included in the analysis (see appendix D for details). The cost per ton of shipping on the vessels was either taken directly from table C-17, or interpolated from the cost data in table C-17 by using a regression equation. A similar methodology was used to estimate current and future costs of woodchip movements, the main differences being vessel sizes and costs per ton. The without-project, -30-foot base condition is therefore a 22,000 DWT average vessel size in 1990, which increases over time to 22,500 DWT in 2010, and remains constant at 22,500 DWT to the end of the study period in 2040.

2.07 Project Benefits. Project benefits were based on the reduction in shipping costs per ton between the authorized channel depth of -30 feet (i.e., the base condition) and 1-foot increments of a deeper channel. This cost saving was multiplied by average annual equivalent tons of log, lumber, and woodchip exports to determine economies of scale benefits. No NED benefits were claimed for labor employment because Grays Harbor County was not designated an area of substantial and persistent unemployment based on standards published by the Water Resources Council in the 11 April 1980 Federal Register. No benefits were claimed for land enhancement because deepwater disposal was assumed to be used for 95 to 100 percent of the dredged material. Up to 5 percent of the material may be too contaminated for ocean disposal in which case upland disposal would be used, but this will be reexamined during advanced engineering and design studies. However, the upland sites are not sites presently designated for industrial development. No benefits were claimed for nighttime delays or tidal delays because vessel operating procedures with respect to nighttime departures and sailing with the tides are not expected to change with a deeper channel. Port records for 1980 showed several vessels departed at night but the Grays Harbor pilots indicated nighttime departures would only occur infrequently, even with a deeper channel. Therefore, it was assumed there would be no change in nighttime departures by deepening the channel. As for tidal delays, the pilots use the tide to provide underkeel clearance, but more important than tidal elevation at departure is the fact that the pilots typically move an outbound vessel against an incoming tide, regardless of whether the vessel is fully or partially loaded. This is done for several reasons: (a) sailing against the tide current provides the pilots with better steering control over the vessel; (b) if the cargo-laden vessel runs aground while exiting the harbor, the incoming tide can lift it off the bottom; and (c) if the vessel loses power by Point Chehalis or the South Jetty, an incoming tide will slow the vessel down and move the vessel back inside the harbor, whereas an outgoing tide could carry the vessel onto Point Chehalis or the South Jetty. The typical procedure followed by the pilots during vessel departures is illustrated in figure C-9. The pilots take the vessel from the dockside

VESSEL DEPARTURE – GRAYS HARBOR



A TO B: DEPARTURE TRANSIT WINDOW AT DOCKS

B TO C: BAR CROSSING WINDOW

FIGURE C-9

berthing area some time between points A and B and cross the bar some time between points B and C. By departing on a flood tide and arriving at the bar near high tide (a 2-3 hour transit from the docks), the pilots attain needed botom clearance for pitch and roll of the vessel. The pilots also, as a matter of practice, time their outbound vessel transits such that the return trip to the dock in the Westport Marina can be made before strong ebb flow begins. During ebb flow, wave steepening is very pronounced along the jetty entrance channel and bar, and creates a hazard to small craft. The pilots indicated that this outbound transit procedure would continue to be followed, even with a deeper channel. Since the with and without project conditions would therefore be the same, no benefits were claimed for reduction in tidal delay costs. Inbound vessels have shallow enough draft that the pilots can bring them into the harbor without any tidal delay on either an ebb or a flood tide.

a. Economies of Scale Benefits - Logs and Lumber. Economies of scale benefits were calculated using the vessel fleet approach, with the fleet expressed as an average vessel size. Shipping cost per ton was estimated for each channel depth in accordance with the average vessel size at each depth. Cost per ton at each depth was calculated and then subtracted from cost per ton at -30 feet (the base condition). The incremental savings from -30 feet were multiplied by average annual tonnage to get average annual benefits. For evaluation of channel improvements downstream of Cow Point, average log vessel size was assumed to start at 22,000 DWT and reach a maximum of 32,800 DWT at a channel depth of -39 feet. For improvements upstream of Cow Point, average log vessel size was assumed to start at 20,700 DWT and reach a maximum of 30,200 DWT (i.e., due to the 600-foot limitation on vessel length), at a channel depth of -37 feet. Vessels in the future timber carrier fleet will range in size up to 45,000 DWT, but as indicated in the fleet analysis in exhibit 2, the majority of world dry-bulk commerce will be carried in vessels in the 25,000 to 35,000 DWT range. Long-term average vessel sizes of 32,800 DWT (below Cow Point) and 30,200 DWT (above Cow Point) are consistent with this forecast.

b. Economies of Scale Benefits - Woodchips. Economies of scale benefits for woodchip vessels were calculated in an identical manner. Growth in woodchip vessel size is presently constrained by the Chehalis River bridge, which limited chip vessel size to approximately 23,600 DWT in 1980. With bridge widening, the largest vessel that could call at the chip facility would be approximately 30,000 DWT (i.e., this vessel has a length of 600 feet), although smaller vessels would continue to be used. Accordingly, the average size woodchip vessel was assumed to reach a maximum of 30,000 DWT at a channel depth of -34 feet. Woodchip vessels have much shallower sail drafts than log vessels, which is why a given channel depth will accommodate a much bigger chip vessel than a log vessel.

2.08 Incremental Analysis By Project Reach. A major element in the cost of the proposed project is the cost of replacing the Union Pacific Railroad Bridge over the Chehalis River at Aberdeen. This bridge currently restricts vessel beam to approximately 85 feet and consequently limits the size of timber carriers and woodchip carriers that can call at the Roderick Timber Company and Weyerhaeuser Company loading facilities upstream of the bridge. Replacing the bridge would provide greater horizontal and vertical clearance and, therefore, allow bigger vessels to transit the upstream segment of the channel. However, the very largest vessels in the timber carrier and woodchip carrier fleets (i.e., 45,000 DWT and 57,000 DWT, respectively) would still be unable to call upstream because of a second constraint imposed by the channel configuration which limits vessel length to about 600 feet and vessel size to approximately 30,000 DWT. The proposed project does not include plans for realinement of this particular part of the channel. Nevertheless, average log vessel size above the bridge could increase approximately 10,000 DWT above the average size of vessels calling there at the present time (i.e., from 20,700 DWT to 30,200 DWT). Grays Harbor log vessel data for 1980 showed the base condition vessel for evaluating improvements above Cow Point should be 20,700 DWT, whereas the base vessel for improvements downstream of Cow Point should be 22,000 DWT. Woodchip vessels could increase about 6,000 DWT (i.e., from 23,600 DWT to 30,000 DWT). It is therefore appropriate to separately evaluate the upstream reach of the proposed channel improvements, including bridge replacement, to determine if the improvements are incrementally justified. For the purpose of incremental analysis, the proposed channel improvements were separated into two reaches: (a) the reach from the outer bar up to and including the Cow Point turning basin (see plate 1) and (b) the reach from the Cow Point turning basin to Cosmopolis, including the UPRR Bridge. The reaches will be referred to as the downstream reach, and upstream reach, respectively. There are no terminal facilities between the Cow Point turning basin and the UPRR bridge, so vessel movements above the bridge are appropriate for economic analysis of the upstream reach.

a. Tonnage and Benefit Allocation. Two companies, Weyerhaeuser and Roderick Timber, will benefit directly from widening and deepening upstream of the UPRR bridge. Numerous smaller mills receive benefits because their woodchips are shipped over the Weyerhaeuser ship dock upstream of the bridge. Benefits of the proposed channel improvements were allocated to the upstream and downstream reaches of the channel in direct proportion to the tonnages of logs, lumber, and chips shipped from each reach. All woodchips exported from Grays Harbor are presently shipped from the Weyerhaeuser chip facility upstream of the UPRR bridge, so all woodchip benefits were allocated to channel improvements above Cow Point. In 1980, log exports were divided approximately 30 percent above the UPRR bridge and 70 percent below, compared with lumber at approximately 20 percent above and 80 percent below. These percentages are based on data from the Port of Grays Harbor monthly shipping reports which include public and private docks. By project year one, 1990, the

proportion of shipments from above the bridge was assumed to increase from 30 to 35 percent for logs and from 20 to 30 percent for lumber. The increase for logs was attributable to a new 500-foot dock built by the Roderick Timber Company in mid-1980. The dock allowed Roderick to ship its logs over its own facilities rather than the Port's facilities and, therefore, created a shift of log tonnage from downstream of the bridge to upstream. Roderick is also a large exporter of logs to China, and China was assumed to account for about 25 percent of projected log exports. The increase for lumber was attributable to the existence of the Weyehaeuser lumber mill upstream of the bridge, the growing relative importance of lumber exports versus log exports, and the fact that the Weyerhaeuser mill has maintained a stable output even in years when other mills in the Grays Harbor area had excess capacity or were shut down. This is due to Weyerhaeuser's reputation among Japanese timber buyers as a reliable source of supply. When markets are depressed in Japan, the smaller marginal mills in the Northwest are the first one to feel it, whereas the larger suppliers, such as Weyerhaeuser, have a competitive advantage in terms of both price and quantity. The allocation of tonnage is summarized in table C-18.

TABLE C-18

TONNAGE ALLOCATION ABOVE AND BELOW COW POINT
1990 to 2040
(Thousands of Short Tons)

Commodity	Total Exports	Above Cow Point - (%)	Below Cow Point - (%)
Logs	2,300	805 (35)	1,495 (65)
Lumber	256	77 (30)	179 (70)
Woodchips	177	177 (100)	0 1/ (0)

1/Based on existing conditions.

b. Benefits and Costs. Transportation benefits were divided between the channel reach above and below Cow Point in direct proportion to the tonnage allocation, as shown in tables C-19, C-20, and C-21. Project first costs and annual costs are summarized in table C-22. The incremental analysis of both reaches is summarized in table C-23. This analysis shows net benefits are maximized if the lower reach is deepened to -38 feet and the upper reach to -36 feet.

2.09 Alternative Evaluations of Upstream Reach.

a. Net Benefits Approach. The economic feasibility of channel improvements upstream of Cow Point and bridge replacement can be evaluated several ways. One way is to look at total transportation benefits above Cow Point and compare these benefits with the cost of channel improvements above Cow Point plus the cost of replacing the UPRR Bridge. This is the approach used in table C-23, which shows the upstream reach is economically justified at any depth below -32 feet.

AD-A115 779 CORPS OF ENGINEERS SEATTLE WA SEATTLE DISTRICT F/G 13/2
INTERIM FEASIBILITY REPORT AND DRAFT ENVIRONMENTAL IMPACT STATE--ETC(U)
JUN 82

UNCLASSIFIED NL

5 OF 6
AD A
115 779

TABLE C-19

ECONOMIES OF SCALE BENEFITS - OUTER BAR TO COW POINT
LOGS AND LUMBER
October 1981 Prices; 7-5/8 Percent Interest

Authorized Channel Depth	Average Vessel Size 1990-2010	Average Vessel Size 2010-2040	Cost Per Ton For Each Vessel1/ 1990-2010	Cost Per Ton For Each Vessel1/ 2010-2040	Average Annual Equivalent Cost Per Ton 1990-2040	Savings Per Ton from 30' 1990-2040	Average Annual Equivalent Tons (x1,000) Logs 1990-2040	Average Annual Equivalent Tons (x1,000) Lumber 1990-2040	Average Annual Benefits (x1,000) Logs 1990-2040	Average Annual Benefits (x1,000) Lumber 1990-2040	Total Avg. Annual Benefits-Outer Bar to Cow Point (x1,000) 1990-2040
30	22,000	22,500	$26.52	$26.16	$26.34	Base Condition			Base Condition		Base Condition
31	23,200	23,700	25.67	25.33	25.50	$0.84	1,495	179	$1,256	$150	$1,406
32	24,400	24,900	24.88	24.57	24.73	1.61	1,495	179	2,407	288	2,695
33	25,600	26,100	24.15	23.21	24.01	2.33	1,495	179	3,483	417	3,900
34	26,800	27,300	23.47	23.86	23.34	3.00	1,495	179	4,485	537	5,022
35	28,800	29,300	22.45	22.21	22.33	4.01	1,495	179	5,995	718	6,713
36	29,200	29,700	22.26	22.03	22.15	4.19	1,495	179	6,264	750	7,014
37	30,400	30,900	21.71	21.50	21.61	4.73	1,495	179	7,071	847	7,918
38	31,600	32,100	21.20	20.99	21.10	5.24	1,495	179	7,834	938	8,772
39	32,800	32,800	20.72	20.72	20.72	5.62	1,495	179	8,402	1,006	9,408
40	32,800	32,800	20.72	20.72	20.72	5.62	1,495	179	8,402	1,006	9,408
41	32,800	32,800	20.72	20.72	20.72	5.62	1,495	179	8,402	1,006	9,408
42	32,800	32,800	20.72	20.72	20.72	5.62	1,495	179	8,402	1,006	9,408
43	32,800	32,800	20.72	20.72	20.72	5.62	1,495	179	8,402	1,006	9,408
44	32,800	32,800	20.72	20.72	20.72	5.62	1,495	179	8,402	1,006	9,408
45	32,800	32,800	20.72	20.72	20.72	5.62	1,495	179	8,402	1,006	9,408

1/Cost per ton = 1,289,139.9999 x $(DWT)^{-0.6187}$: 100. See exhibit 2.

TABLE C-20

ECONOMIES OF SCALE BENEFITS - *COW POINT TO COSMOPOLIS*
LOGS AND LUMBER
October 1981 Prices; 7-5/8 Percent Interest

Authorized Channel Depth	Average Vessel Size		Cost Per Ton For Each Vessel[1/]		Average Annual Equivalent Cost Per Ton	Savings Per Ton from 30'	Average Annual Equivalent Tons (x1,000)		Average Annual Benefits (x1,000)		Total Avg. Annual Benefits-Outer Bar to Cow Point (x1,000)
	1990-2010	2010-2040	1990-2010	2010-2040	1990-2040	1990-2040	Logs 1990-2040	Lumber 1990-2040	Logs 1990-2040	Lumber 1990-2040	1990-2040
30	20,700	21,200	$27.54	$27.14	$27.34	Base Condition			Base Condition		Base Condition
31	22,200	22,700	26.38	26.01	26.20	$1.14	805	77	$918	$88	$1,005
32	23,700	24,200	25.33	25.00	25.17	2.17	805	77	1,747	167	1,914
33	25,200	25,700	24.39	24.09	24.24	3.10	805	77	2,495	239	2,734
34	26,700	27,200	23.53	23.26	23.40	3.94	805	77	3,172	303	3,475
35	28,200	28,700	22.75	22.50	22.63	4.71	805	77	3,791	363	4,154
36	29,700	30,200	22.03	21.80	21.92	5.42	805	77	4,363	417	4,780
37	30,200	30,200	21.80	21.80	21.80	5.54	805	77	4,460	426	4,886
38	30,200	30,200	21.80	21.80	21.80	5.54	805	77	4,460	426	4,886
39	30,200	30,200	21.80	21.80	21.80	5.54	805	77	4,460	426	4,886
40	30,200	30,200	21.80	21.80	21.80	5.54	805	77	4,460	426	4,886
41	30,200	30,200	21.80	21.80	21.80	5.54	805	77	4,460	426	4,886
42	30,200	30,200	21.80	21.80	21.80	5.54	805	77	4,460	426	4,886
43	30,200	30,200	21.80	21.80	21.80	5.54	805	77	4,460	426	4,886
44	30,200	30,200	21.80	21.80	21.80	5.54	805	77	4,460	426	4,886
45	30,200	30,200	21.80	21.80	21.80	5.54	805	77	4,460	426	4,886

1/Cost per ton = 1,289,139.9999 x $(DWT)^{-0.6187}$: 100. See exhibit 2.

TABLE C-21

ECONOMIES OF SCALE BENEFITS - COW POINT TO COSMOPOLIS
WOODCHIPS
October 1981 Prices; 7-5/8 Percent Interest

Authorized Channel Depth	Average Vessel Size 1990-2010	Average Vessel Size 2010-2040	Cost Per Ton For Each Vessel1/ 1990-2010	Cost Per Ton For Each Vessel1/ 2010-2040	Average Annual Equivalent Cost Per Ton 1990-2040	Savings Per Ton from 30' 1990-2040	Average Annual Equivalent Tons (x1,000) 1990-2040	Avg. Annual Woodchip Benefits 1990-2040	Avg. Annual Log Benefits (x1,000) 1990-2040	Total Upstream Benefits (x1,000) 1990-2040
30	23,600	24,000	$31.30	$31.08	$31.19	Base Condition		Base Condition	Base Condition	Base Condition
31	24,600	25,000	30.76	30.55	30.66	$0.53	177	$93,800	$1,005	$1,099
32	25,600	26,000	30.24	30.05	30.15	1.04	17[illegible]	18[illegible],100	1,914	2,098
33	28,000	30,000	29.12	28.28	28.71	2.48	177	438,900	2,734	3,173
34	30,000	30,000	28.28	28.28	28.28	2.91	177	515,100	3,475	3,990
35	30,000	30,000	28.28	28.28	28.28	2.91	177	515,100	4,154	4,669
36	30,000	30,000	28.28	28.28	28.28	2.91	177	515,100	4,780	5,295
37	30,000	30,000	28.28	28.28	28.28	2.91	177	515,100	4,886	5,401
38	30,000	30,000	28.28	28.28	28.28	2.91	177	515,100	4,886	5,401
39	30,000	30,000	28.28	28.28	28.28	2.91	177	515,100	4,886	5,401
40	30,000	30,000	28.28	28.28	28.28	2.91	177	515,100	4,886	5,401
41	30,000	30,000	28.28	28.28	28.28	2.91	177	515,100	4,886	5,401
42	30,000	30,000	28.28	28.28	28.28	2.91	177	515,100	4,886	5,401
43	30,000	30,000	28.28	28.28	28.28	2.91	177	515,100	4,886	5,401
44	30,000	30,000	28.28	28.28	28.28	2.91	177	515,100	[illegible],886	5,401
45	30,000	30,000	28.28	28.28	28.28	2.91	177	515,100	4,886	5,401

1/Cost per ton = 222,377.1183 x $DWT^{-0.4234}$ ÷ 100. See exhibit 2.

TABLE C-22

SUMMARY OF PROJECT FIRST COSTS1/
October 1981 Prices; 7-5/8 Percent Interest

	Federal	Non-Federal	Total
Outer Bar Reach - Cow Point Reach	$38,100,000	$525,000	$38,625,000
Upstream of Cow Point Reach	30,100,000	2,575,000	32,675,000
TOTAL (Rounded)	$68,200,000	$3,100,000	$71,300,000

SUMMARY OF TOTAL PROJECT AVERAGE ANNUAL FIRST COSTS1/
October 1981 Prices; 7-5/8 Percent Interest

	Federal	Non-Federal	Total
Outer Bar - Cow Point Reach	$5,062,000	$221,000	$5,283,000
Upstream of Cow Point Reach	2,576,000	221,000	2,797,000
TOTAL (Rounded)	$7,638,000	$442,000	$8,080,000

1/Detailed project cost data, including Truman-Hobbs cost apportionment of the UPRR bridge, can be found in appendix D.

TABLE C-23

SUMMARY OF PROJECT BENEFITS AND COSTS BY PROJECT REACH
October 1981 Prices; 7-5/8 Percent Interest
(Thousands of Dollars)

	Outer Bar to Cow Point			Upstream of Cow Point		
Authorized Channel Depth	Avg. Ann. Benefits	Avg. Ann. Costs	Net Benefits	Avg. Ann. Benefits	Avg. Ann Costs	Net Benefits
30	Base			Base		
31	$1,406	$1,380	$26	$1,099	$2,250	$-1,151
32	2,695	1,920	775	2,098	2,350	-292
33	3,900	2,460	1,440	3,173	2,450	723
34	5,022	3,000	2,022	3,990	2,560	1,430
35	6,713	3,540	3,173	4,669	2,675	1,944
36	7,014	4,100	2,914	5,295	2,797	2,498*
37	7,918	4,680	3,238	5,401	2,940	2,461
38	8,772	5,283	3,489*	5,401	3,100	2,301
39	9,408	5,990	3,418	5,401	3,287	2,121
40	9,408	6,810	2,598	5,401	3,470	1,931
41	9,408	7,530	1,878	5,401	3,720	1,681
42	9,408	8,430	978	5,401	3,920	1,481
43	9,408	9,360	48	5,401	4,130	1,271
44	9,408	10,290	-882	5,401	4,360	1,041
45	9,408	11,320	-1,912	5,401	4,620	781

*Point of maximization of net benefits.

b. Least-Cost Approach. A second way of evaluating the economic feasibility of bridge replacement and upstream channel improvements is to determine which of the following would be the least-cost alternative: (1) replace the bridge so larger vessels can call upstream or (2) leave the bridge as is and truck the logs and lumber to the Port facilities below the bridge where they could be loaded on larger vessels. Woodchip exports can be ignored since there is presently no chip loading facility at the Port docks and, therefore, no alternative to loading the chip vessels at the Weyehaeuser dock. The two forest products companies located above the bridge, Roderick Timber Company (logs) and Weyerhaeuser Company (logs and lumber), both own their own docks. By shipping over their own docks, these companies can save Port charges of $24.47/thousand board feet (Mbf) on logs and $15.78/Mbf for lumber (1981 prices). In addition, trucking costs from these private docks to the Port docks are $8.04/Mbf for logs and $2.11/Mbf for lumber. The lumber rate is based on an hourly rate plus a tonnage rate as follows:
8 loads/day at 14,000 bf/load=112,000 bf/day and 1-hour/load for 8-hours at $29.53/hour=$236.24/day; $236.24:112,000=$2.11/Mbf. Summarizing, the added costs of trucking the logs and lumber from the private docks to the Port docks and shipping over the Port docks are $32.51/Mbf for logs and $17.89/Mbf for lumber. From table C-18, tonnages projected for shipment from the upstream facilities are logs at 805,000 tons per year (i.e., 141,228 Mbf) and lumber at 77,000 tons per year (i.e., 29,807 Mbf). Therefore, the total added cost of not replacing the bridge and making upstream channel improvements is $4,591,322 per year for logs and $533,247 per year for lumber, for a total added annual cost of $5,124,569. As shown in table C-23, this cost exceeds all of the average annual costs of the upstream reach, regardless of channel depth. This indicates that under the assumptions used in this analysis, it would be cheaper to replace the bridge and improve the channel above Cow Point than to require these companies to use the Port facilities.

c. Cost Per Ton Approach. A third approach is to evaluate the upstream improvements on a cost per ton basis. The average annual cost of bridge replacement and channel improvements to -36 feet would be $2,797,000 per year as shown in table C-22. Dividing this annual cost by projected upstream log and lumber tonnages of 882,000 tons per year, places the bridge replacement and channel improvement costs at $3.17 per ton per year. From table C-20, average log vessel size on the -36-foot upstream channel would maximize at approximately 30,200 DWT and cost $21.80/ton. This is the shipping cost per ton with upstream improvements. Based on 1980 data, the average size of all the timber carriers that called above the UPRR bridge was 20,735 DWT, at a 1981 cost of $27.51 per ton. This is the shipping cost per ton without upstream improvements. Therefore, the upstream reach improvements would cost $3.17 per ton and save $5.71 per ton, (i.e., $27.51-$21.80) giving a savings-investment ratio of 1.80 (i.e., $5.71-$3.17). The break-even point on bridge replacement would be a vessel costing $24.97 per ton (i.e., $24.97-$21.80=$3.17). At this point, the cost per ton of the upstream improvements would just equal the savings per ton permitted by

the improvements. An average vessel size of approximately 24,200 DWT would have this cost per ton. Accordingly, vessels calling upstream over the 1990-2040 project life would have to exceed 24,200 DWT, on the average, in order for bridge replacement to make economic sense. This would not appear to be a formidable obstacle since average log vessel size for the entire harbor was already at 22,000 DWT in 1980. In summary, bridge replacement appears economically justified based on all three analyses and their underlying assumptions.

2.10 Current Cost of Alternative Movement. One alternative to the proposed widening and deepening project in Grays Harbor is to truck the forest products to a competitive harbor that presently has a channel deeper than the -30-foot channel in Grays Harbor, and ship the products from there. The Port of Tacoma (77 miles from Aberdeen) has a -35-foot channel and the Port of Longview (95 miles from Aberdeen) has a 40-foot channel. Trucking costs, which were obtained from the Washington State Utilities and Transportation Commission, consist of a base rate of $0.87/1,000 pounds and a schedule of cents per mile rates that vary depending on the quality of the road driven. A truckload of logs weighs a minimum of 47,000 pounds and carries 4,200 board feet of logs. Driving distance to Tacoma is 77 miles on "A" roads (i.e., paved roads at 3.7 cents/mile), plus 1 mile at both ends on "C" roads (i.e., other than surfaced roads from the Port docks to the main highway at 6.5 cents/mile). The computed trucking cost is $0.87/1,000 pounds+$2.85 (77 miles at 3.7¢/mile) + $0.13 (2 miles at 6.5¢/mile) for a total of $3.85/1,000 pounds, or $7.70 per ton. A truckload of lumber would cost approximately the same per ton. Therefore, a timber company in Grays Harbor would have to save at least $7.70/ton to justify trucking the company's logs to the -35-foot channel in Tacoma. Referring to table C-19, the maximum long-term savings per ton between a -30-foot and -35-foot channel (at Grays Harbor) are $4.01 per ton, considerably less than the required $7.70/ton. Trucking would also save the proposed project costs of $5,283,000 per year below Cow Point and $2,797,000 per year above Cow Point, or a total of $8,080,000 per year. Dividing by total projected exports of 2,733,000 tons per year equals a project cost of $2.96 per ton. Vessel savings of $4.01 per ton plus project cost savings of $2.96 per ton, or $6.97 per ton, is still less than the trucking cost of $7.70 per ton. (Savings per ton would be very similar for the -35-foot channel in Tacoma where the extra sailing time to Japan would only add about 3 percent to the figures in table C-19. Tacoma is 244 nautical miles further from Japan than is Grays Harbor, so at 16 knots per vessel, the maximum additional sailing time from Japan would be 15 hours.) In summary, trucking the logs and lumber to Tacoma would cost more money than it would save.

2.11 Sensitivity Analysis. The maximization of net benefits shown in table C-23 is sensitive to the assumption of how large the average sizes of the timber and woodchip carrier fleets are projected to get in Grays Harbor. The analysis assumed the timber carrier fleet will increase in average size from 22,000 DWT to 32,800 DWT downstream of Cow Point, and from 20,700 DWT to 30,200 DWT upstream of Cow Point. The woodchip fleet

vessels, also upstream of Cow Point, were projected to increase from an average of 23,600 DWT to an average of 30,000 DWT. The sensitivity of project benefits to fleet size appears to be more critical downstream of Cow Point, because fleet size above Cow Point is and will be limited to a length of 600 feet and therefore a maximum vessel size of approximately 30,000 DWT. The project benefits take account of this limitation. If vessels do not reach 30,000 DWT above Cow Point, a channel shallower than -36 feet would suffice, how much shallower depending on vessel size. Table C-20 gives a good indication of channel depth vs. average vessel size above Cow Point. For an average vessel size smaller than 30,000 DWT, the appropriate channel depth can be read directly from the table. Similarly, table C-19 shows optional channel depths downstream of Cow Point for vessels smaller than 32,800 DWT. If average vessel size increases beyond 32,800 DWT, either because the fleet forecast erred on the low side or because new commodities are shipped from Grays Harbor in vessels other than timber carriers and also larger than 32,800 DWT, then a channel deeper than -38 feet would be needed. How much deeper again depends on vessel size. A high vessel growth scenario for channel improvements below Cow Point is summarized in tables C-24 and C-25. The analysis shows that if vessels are projected to increase in size up to 40,500 DWT, on average, the channel downstream of Cow Point should be deepened to -39 feet rather than the proposed -38 feet. A vessel fleet averaging 40,500 DWT would have a fully loaded fleet draft of 36 feet. In other words, the timber carrier fleet can increase in size from an average of 32,800 DWT to an average of 40,500 DWT, an increase of 7,700 DWT, but the fleet's average draft would increase only 1 foot. Accordingly, recommended channel depth is not critically sensitive to pinpoint accuracy in the fleet forecast.

TABLE C-24

ECONOMIES OF SCALE BENEFITS - OUTER BAR TO COW POINT
HIGH VESSEL GROWTH SCENARIO
LOGS AND LUMBER
October 1981 Prices; 7-5/8 Percent Interest

Authorized Channel Depth	Average Vessel Size		Cost Per Ton For Each Vessel 1/		Average Annual Equivalent Cost Per Ton	Savings Per Ton from 30'	Average Annual Equivalent Tons (x1,000)		Average Annual Benefits (x1,000)		Total Avg. Annual Benefits- Outer Bar to Cow Point (x1,000)
	1990-2010	2010-2040	1990-2010	2010-2040	1990-2040	1990-2040	Logs 1990-2040	Lumber 1990-2040	Logs 1990-2040	Lumber 1990-2040	1990-2040
30	22,000	22,500	$26.52	$26.16	$26.34	Base Condition			Base Condition		Base Condition
31	23,200	23,700	25.67	25.33	25.50	$0.84	1,495	179	$1,256	$150	$1,406
32	24,400	24,900	24.88	24.57	24.73	1.61	1,495	179	2,407	288	2,695
33	25,600	26,100	24.15	23.86	24.01	2.33	1,495	179	3,483	417	3,900
34	26,800	27,300	23.47	23.21	23.34	3.00	1,495	179	4,485	537	5,022
35	28,800	29,300	22.45	22.21	22.33	4.01	1,495	179	5,995	718	6,713
36	29,200	29,700	22.26	22.03	22.15	4.19	1,495	179	6,264	750	7,014
37	30,400	30,900	21.71	21.50	21.61	4.73	1,495	179	7,071	847	7,918
38	31,600	32,100	21.20	20.99	21.10	5.24	1,495	179	7,834	938	8,772
39	32,800	33,300	20.72	20.33	20.53	5.81	1,495	179	8,686	1,040	9,726
40	34,000	34,500	20.26	20.08	20.17	6.17	1,495	179	9,224	1,104	10,328
41	35,200	35,700	19.83	19.66	19.75	6.59	1,495	179	9,852	1,180	11,032
42	36,400	36,900	19.42	19.26	19.34	7.00	1,495	179	10,465	1,253	11,718
43	37,600	38,100	19.04	18.88	18.96	7.38	1,495	179	11,033	1,321	12,354
44	38,800	39,300	18.67	18.52	18.60	7.74	1,495	179	11,571	1,385	12,956
45	40,000	40,500	18.32	18.18	18.25	8.09	1,495	179	12,094	1,448	13,542

1/Cost per ton = 1,289,139.9999 x $(DWT)^{-0.6187}$ + 100. See exhibit 2.

TABLE C-25

SENSITIVITY ANALYSIS - OUTER BAR TO COW POINT
High Vessel Growth Scenario
October 1981 Prices; 7-5/8 Percent Interest
(Thousands of Dollars)

Authorized Channel Depth	Outer Bar to Cow Point Avg. Ann. Benefits	Avg. Ann. Costs	Net Benefits
30	Base Condition		
31	$1,406	$1,380	$26
32	2,695	1,920	775
33	3,900	2,460	1,440
34	5,022	3,000	2,022
35	6,713	3,540	3,173
36	7,014	4,100	2,914
37	7,918	4,680	3,238
38	8,712	5,283	3,429
39	9,726	5,990	3,736*
40	10,328	6,810	3,518
41	11,032	7,530	3,502
42	11,718	8,430	3,288
43	12,354	9,360	2,994
44	12,956	10,290	2,666
45	11,320	11,320	2,222

*Point of maximization of net benefits.

TABLE C-26

SUMMARY OF NET BENEFIT MAXIMIZATION
October 1981 Prices; 7-5/8 Percent Interest
(Thousands of Dollars)

Project Reach	Depth (MLLW)	Avg. Annual Benefits	Avg. Annual Costs	Net Benefits	B-C Ratio
Outer Bar to Cow Point	-38 feet	$8,772	$5,283	$3,489	1.7
Cow Point to Cosmopolis	-36 feet	5,295	2,797	2,498	1.9
Total Project		$14,067	$8,080	$5,987	1.7

2.12 Summary. This appendix on economic evaluation of proposed channel improvements and UPRR bridge replacement in Grays Harbor looked in detail at projected commodity movements and projected fleet sizes. The economic analysis of transportation cost savings was based on a comparison of with- and without-project conditions, as prescribed by the Principles and Standards Procedures for deep draft navigation. The analysis also included a nonstructural alternative of trucking forest products from Grays Harbor to Tacoma, where a -35-foot channel already exists, rather than deepening Grays Harbor. The analysis showed the nonstructural alternative (i.e., trucking) would cost more money than it would save. A sensitivity analysis based on average vessel size downstream of Cow Point showed the proposed project depth of -38 feet in this reach is not critically sensitive to projected fleet size in that the projected average fleet size could be underforecasted by 7,700 DWT, but the recommended channel depth would increase only 1 foot. The results of the economic evaluation showed net benefits were maximized if the reach of the channel from the outer bar up to and including the Cow Point turning basin were deepened to -38 feet and if the reach from Cow Point to Cosmopolis were deepened to -36, and the UPRR bridge replaced to allow greater horizontal and vertical clearance. The maximization is summarized in table C-26.

EXHIBIT 1

COMMODITY FORECASTS

GRAYS HARBOR, WASHINGTON

PRECEDING PAGE BLANK-NOT FILMED

TABLE OF CONTENTS

TABLE OF CONTENTS (con.)

TABLES

TABLE OF CONTENTS (con.)

SECTION 1

FORESTS IN THE GRAYS HARBOR TRIBUTARY AREA

1. Introduction. The land surrounding Grays Harbor is commercial forest land of high productivity. Coastal Washington is a heavily forested region with forests covering over 90 percent of the area. These forests are among the most productive in the nation. The trees are mainly softwoods (see table 3) of sawtimber size, stands are well stocked, and timber volume per acre is accordingly high. Almost 70 percent of the commercial forest land in coastal Washington is classified as highly productive. In contrast, less than 10 percent of commercial forest land in the United States as a whole is classed as highly productive. Commercial forest land in coastal Washington carries a total timber volume of approximately 5,018 cubic feet per acre, compared with a national average of 1,373 cubic feet per acre.

2. Definition of the Tributary Area. The forest area considered tributary to the Port of Grays Harbor includes Pacific and Grays Harbor Counties, the western half of Jefferson County, and the southwestern corner of Clallam County. This area encompasses approximately 1,884,300 acres of commercial forest land of which approximately 40 percent are owned by major forest industry companies, 35 percent by public agencies, and

TABLE 1

OWNERSHIP OF COMMERCIAL FOREST LAND IN THE TRIBUTARY AREA

Owner of Commercial Forest Land	Area Tributary to the Port of Grays Harbor (000 acres)	(percent)
Weyerhaeuser Company	461	24.5
Washington State	300	15.9
ITT Rayonier, Inc.	236	12.5
United States Forest Service	204	10.8
Indian	165	8.8
Simpson Timber Company	0	0.0
Boise Cascade Corporation	54	2.9
Crown Zellerbach Corporation	0	0.0
Grays Harbor County	32	1.7
Miscellaneous Small	432	22.9
Total	1,884	100.0

Source: Forests Tributary to the Port of Grays Harbor, Greenacres Consulting Corp., July, 1977.

25 percent by small forest industry companies or individuals. Ownerships are shown in table 1. Commercial forests in the tributary area contain approximately 8.4 billion cubic feet of timber, or roughly 45.36 billion board feet using a conversion factor of 5.4 board feet Scribner per cubic foot. Seventy-four percent or 6.2 billion cubic feet is in softwood sawtimber. Thus, approximately 2 percent of the nation's softwood sawtimber is tributary to the Port of Grays Harbor. The total volume of timber in the tributary area by broad ownership class and type of wood is shown in table 2 and by species composition in table 3.

TABLE 2

TOTAL TIMBER VOLUME BY OWNERSHIP CLASS
TRIBUTARY TO THE PORT OF GRAYS HARBOR

Owner of Commercial Forest Land	Volume (Million Cubic Feet)	Percent
Private		
Softwood	4,722	56
Hardwood	677	8
Public		
Softwood	2,962	35
Hardwood	75	1
Total	8,436	100

Source: Forests Tributary, 1977.

TABLE 3

SPECIES COMPOSITION OF TOTAL TIMBER VOLUME
TRIBUTARY TO THE PORT OF GRAYS HARBOR

Species	Volume (Million Cubic Feet)	Percent
Softwoods		
Hemlock	4,534	54
Douglas fir	1,153	14
Western redcedar	768	9
True fir	692	8
Sitka spruce	461	5
Other	76	1
Hardwoods		
Red alder	707	8
Other	45	1
Total	8,436	100

Source: Forests Tributary, 1977

3. Future Forest Condition. During a century of economic development in the west, patterns of land use have continually changed. Early development of the Pacific Northwest was marked by clearing commercial forest land for agricultural use. Additional clearing for agriculture is not anticipated but there are other significant shifts to uses such as urbanization, recreation, reservoirs, roads, and powerlines. The future status of timber production is affected by these other uses on commercial forest land. Urbanization will occur as a result of the economic growth of the Grays Harbor area and as a result of the large growth in population and industrialization occurring in the Puget Sound area east of Grays Harbor. Demand for outdoor recreation is increasing in coincidence with an increasing standard of living and shorter work weeks. Development of better forest road and highway systems will also impact commercial forest land area. Present forest road density in the tributary area does not exceed 2 miles per square mile of forest land. As forest management intensified in the future, forest roads will reach an estimated density of approximately 5 miles per square mile by the year 2020. Considering these shifts in land use, commercial forest land in the tributary area is forecast to decrease by 6.5 percent by 2020. The present area of commercial forest totaling 1,884,000 acres will be reduced to approximately 1,762,000 acres.

4. Future Yield and Inventory. Future forests of the tributary area will be significantly different from the forests that exist today. In general, the total timber inventory of the future forests will be lower than that of the present forests. On the other hand, the yield of wood from the future forests will be higher than the current yield. Public lands which carry a high percentage of old growth timber will undergo a steady reduction in inventory and a steady increase in growth or potential yield. Private ownerships with similar old growth stands will reduce inventory faster than public agencies in order to reduce capital investments. Such stands, when liquidated, will provide space for younger and faster growing forests. Yields and inventories projected for future forest have been developed by forest scientists in terms of management practices, site quality, and species zone. Average yield and inventory (for softwoods only) for public and private lands are shown in table 4.

TABLE 4

FUTURE INVENTORY AND YIELD
FOR COMMERCIAL FORESTS OF THE TRIBUTARY AREA

	Private Lands	Public Lands
Inventory (cubic feet per acre)	1,892	1,475
Yield (cubic feet per acre per year)	187	147

Source: Forests Tributary, 1977.

5. Future Harvest Potential. Future average annual harvest potentials for the area tributary to the Port of Grays Harbor are comprised of two components: annual growth and reduction of inventory. Future forests will have a higher growth rate and a lower inventory than those of present forests. Assuming that the reduction of inventory and increase of growth rate will be achieved in an orderly and uniform manner, then annual harvest potentials could be as forecasted in table 5. In reality, actual harvests and potential harvests can be quite erratic due to the number of variables involved. Actual harvests are unlikely to match forecasted potential harvests every year. The important aspects of table 5 are the upward trend in potential harvests and the range of harvest potentials from 335 million to 371 million cubic feet.

TABLE 5

HARVEST POTENTIALS FOR THE AREA
TRIBUTARY TO THE PORT OF GRAYS HARBOR
(Million Cubic Feet)

	1980	1990	2000	2010	2020
Private Ownership					
Softwood growth	160	165	170	176	181
Softwood from inventory	63	63	63	63	63
Hardwood growth	8	8	8	8	8
Hardwood from inventory	8	8	9	8	8
Public Ownership					
Softwood growth	63	67	70	74	78
Softwood from inventory	31	31	31	31	31
Hardwood growth	1	1	1	1	1
Hardwood from inventory	1	0	1	0	1
Total	335	343	353	361	371

Source: Forests Tributary, July 1977.

6. Local Demand for Wood. Demand for wood from the area tributary to the Port of Grays Harbor comes from two sources, local industry and overseas industry. Local demand is based on demand for sawlogs; veneer logs for plywood; miscellaneous wood products such as poles, piling, posts, and shingles; and pulpwood for paper and allied products. The Forests Tributary study relied on Forest Service projections for local industry demand for wood. These projections are summarized in table 6 and are deducted from the harvest potential, thereby showing wood potentially available for export. For Grays Harbor, wood available for export must be of sufficient quantity to serve present and future export markets

for logs, lumber, and woodchips. Forecasts of future export demand for logs, lumber, and woodchips from Grays Harbor are quite diverse. The following section analyzes a variety of log export forecasts and shows how the forecasts relate to historic exports and to each other.

TABLE 6

LOCAL DEMAND FOR WOOD AND
WOOD POTENTIALLY AVAILABLE FOR EXPORT

	1980	1990	2000	2010	2020
	(million cubic feet)				
Harvest Potential	335	343	353	361	371
Local Consumption	159	187	199	212	218
Balance For Export	176	156	154	149	153
(Balance in 1,000 short tons)1/	5,417	4,802	4,740	4,586	4,709

Source: Forests Tributary, 1977.

1/Estimated based on 1 cubic foot x 5.4 board feet Scribner/cubic foot x .0057 = short tons.

NOTE: The Greenacres Consulting Corp, preparers of this table, confirmed in a June 1981 telephone interview that the numbers were valid for 1981-1982.

SECTION 2

FORECAST OF FUTURE LOG EXPORTS

1. Historical Log Exports. Log exports have historically been the economic mainstay of Grays Harbor. Total volumes of log exports for the period 1961 to 1980 are shown in table 7. Exports rose rapidly during the period 1962 to 1968, but the growth rate slowed from 1968 to 1980. Major drops in export volumes occurred in 1971, 1974, and 1975. The low in 1971 was caused by a dock strike, and the lows of 1974 and 1975 resulted from distortions to the Japanese economy caused by rapidly increasing energy costs. Volumes ranging from 2.7 million to 2.8 million short tons were reached in 1972, 1973, 1976, 1978, and 1980, with the average tonnage in these 6 years at approximately 2.7 million short tons. The highest log export volume occurred in 1979 with 3.6 million short tons. Census data shows that in 1979 log exports were 4.8 percent of total major commodity exports for the United States, 25.3 percent for the Pacific Coast, 34.[illegible] percent for the Pacific Northwest, 48.4 percent for the State of Washington, and 90.4 percent for Grays Harbor. As the geographical area is condensed and focused on Grays Harbor, log exports as a key commodity in foreign exports change in importance from relatively insignificant at the national level to total dominance at the Grays Harbor level. Nineteen percent of total United States log exports in 1979 were shipped from Grays Harbor.

TABLE 7

HISTORICAL LOG EXPORTS - GRAYS HARBOR
(Thousands of Short Tons)

Year	Volume	Year	Volume
1961	192	1971	1,810
1962	120	1972	2,705
1963	286	1973	2,719
1964	634	1974	2,191
1965	973	1975	2,096
1966	1,160	1976	2,735
1967	1,754	1977	2,342
1968	2,224	1978	2,857
1969	2,130	1979	3,585
1970	2,140	1980	2,779

Source: Port of Grays Harbor Annual Reports.

2. Market Analysis. All logs exported from Grays Harbor go to the Orient, mainly to Japan but also to South Korea and China. Japan is expected to remain the dominant customer for logs, lumber, and woodchip exports originating in the Grays Harbor tributary area. Accordingly,

TABLE 8

PERCENTAGE DISTRIBUTION OF LOG, LUMBER, AND WOODCHIP EXPORTS
FROM WASHINGTON STATE TO PACIFIC RIM NATIONS
1974 to 1978 Average
(Percent)

	Puget Sound1/			Washington Coast2/			Lower Columbia (Wash)3/		
Trade Route	Logs	Lumber	Wood Chips	Logs	Lumber	Wood Chips	Logs	Lumber	Wood Chips
Japan	88.7	59.8	93.6	89.5	98.0	100.0	98.1	48.1	99.0
East Asia4/	7.8	0.3	0.0	10.5	0.2	0.0	1.9	2.3	0.0
Southeast Asia5/	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Oceania6/	0.0	22.4	0.0	0.0	0.0	0.0	0.0	15.0	0.0
Pacific Rim Total	96.5	82.5	93.6	100.0	98.2	100.0	100.0	65.4	99.0

Source: Census Tapes 305-705; Port System Study, 1980.

1/Puget Sound ports include Bellingham, Anacortes, Everett, Seattle, Tacoma, Olympia, Bremerton, Port Anageles, and Port Townsend.

2/Washingtcn coast port is Grays Harbor.

3/Lower Columbia ports in Washington include Longview, Kalama, and Vancouver.

4/Includes North Korea, South Korea, USSR-Pacific, Hong Kong, China, and Taiwan.

5/Includes the Philippines, North Vietnam, South Vietnam, Cambodia, Laos, Thailand, Indonesia, Malaysia, and Singapore.

6/Includes Australia and New Zealand.

projected levels of Grays Harbor forest product exports are expected to be directly but not exclusively related to future Japanese consumption levels. Markets in China and other Pacific Rim countries have enormous growth potential and are just beginning to develop. Some forest products are also exported from Grays Harbor to the Mediterranean. Japan's dominance as the major forest products trading partner of the Pacific Northwest is illustrated in table 8. Data averaged for the 1974-1978 period shows that 88.7, 89.5, and 98.1 percent of the log exports originating from Puget Sound, Washington coast, and lower Columbia-Washington ports were bound for Japan. Similar percentage distributions are shown for lumber and woodchips. Log exports to East Asia (7.8 percent of the Puget Sound total and 10.5 percent of the Washington coast total) were primarily shipped to South Korea. The majority of logs exported to South Korea are processed into lumber and then exported to Japan. As a result, future levels of South Korean demand for log exports from Grays Harbor are also expected to be strongly tied to future Japanese timber consumption patterns.

a. Historical Japanese Forest Products Demand. Historically, Japan has imported large volumes of logs rather than finished lumber from the United States. Thousands of family owned Japanese sawmills process logs into hundreds of sizes that are unique to Japanese residential construction methods. Some of the unique dimensions are cut at the construction site of the homes, rather than at the sawmills. In 1978, approximately 69 percent of United States world log exports were sold to Japan. The high volume of exports to Japan can be explained by the price competitiveness of United States softwood logs, which have historically been priced lower than competing Japanese species, as shown in table 9. The price of United States Douglas fir as a percentage of the price of Japanese cedar, a competing species for structural lumber, ranged from 80.4 percent in 1975 to 86.9 percent during September 1979.

TABLE 9

JAPANESE LOG PRICES
1975 to 1979
(Yen Per Cubic Meter)

	Domestic Japanese Cedar	Imported U.S. Douglas Fir	U.S. Price As A Percent of Japanese Price
1975	32,200	25,900	80.4
1976	32,400	27,200	83.9
1977	31,600	26,900	85.1
1978	31,100	25,100	80.7
1979 (September)	39,100	34,000	86.9

Source: Japanese Ministry of Agriculture, Forestry, and Fisheries; Port System Study, 1980.

Japan also imported approximately 30 percent of total United States finished lumber exports to the world over the period 1975 through 1978. United States world lumber export levels remained relatively stable over this period, as a strong domestic United States demand maintained a level of higher prices and, therefore, reduced the incentive to sell to foreign export markets. The demand for housing is the primary driving force of Japanese demand for softwood logs and finished lumber. Approximately 77 percent of sawn lumber consumed in Japan is used in housing construction. Fluctuations in Japanese lumber and plywood demand patterns closely parallel changes in the number of new housing starts, as shown in table 10. An increase in housing starts from 1975 to 1976 was accompanied by an increase in lumber and plywood demand from 1975 to 1976. Housing starts dipped in 1977 and rose in 1978. Lumber and plywood demand behaved in an identical manner. The increase in Japanese housing demand from 1975 to 1976 was also reflected in a rise in log exports from Grays Harbor but not in lumber exports. A similar correlation occurred between 1976 and 1977 when housing starts dropped and log exports dropped but lumber exports increased. Not until 1978 did log and lumber exports both increase in response to increased Japanese demand for lumber and plywood. Lumber exports in 1978 increased by approximately 31 percent over the 1977 volume compared with a 22 percent increase in log exports. However, the continued Japanese preference for softwood logs instead of finished lumber is underscored by export data of table 10 which shows log exports dominated lumber exports by a factor of roughly 18.5 tons to 1 ton from 1975 through 1979.

TABLE 10

CORRELATION OF JAPANESE HOUSING STARTS, LUMBER, AND PLYWOOD DEMAND WITH LOG AND LUMBER EXPORTS FROM GRAYS HARBOR
(Thousands of Short Tons)

Year	Japanese Housing Starts	Japanese Lumber Demand	Japanese Plywood Demand	Grays Harbor Log Exports	Grays Harbor Lumber Exports
1975	1,356,286	50,913.7	10,279.2	2,096	135
1976	1,523,844	52,802.5	11,903.9	2,735	112
1977	1,508,260	52,038.9	11,700.0	2,342	116
1978	1,549,362	52,992.0	12,512.0	2,857	152
1979	729,159*	52,348.0*	12,696.0*	3,585	232

Source: Port System Study, 1980.

*January through June only.

b. Future Japanese Forest Products Demand. Future levels of Japanese timber consumption were projected in the 1980 Port System Study to be a function of new household formation and resultant changes in housing starts. Continued maturing of Japan's population was reflected by a

projected decline in future levels of new household formation from 449,000 annually in the 1980 to 1985 period to 386,000 new households annually in the 1985 to 1990 period, as shown in table 11. Accordingly, new housing starts were also projected to decline to a yearly average of 1.23 million units from 1980 to 1985 and to 1 million units annually from 1985 to 1990. New housing starts exceeded 1.5 million units per year in the late 1970's (see table 10).

TABLE 11

PROJECTED JAPANESE NEW HOUSEHOLD FORMATION
AND NEW HOUSING STARTS
1980 to 1990

	Annual Number of New Households	Annual Number of New Housing Starts
1980 to 1985	449,000	1,225,000
1985 to 1990	386,411	1,000,000
Annual Percent Growth 1980-90	-1.49	-2.01

Source: Sanwa Bank; Port System Study, 1980.

3. Alternative Log Export Forecasts. The 1980 Port System Study and several other studies have projected log exports from Grays Harbor between 1980 and the year 2000 or later. These forecasts and their major assumptions wil be reviewed and compared in this section. Also, an analysis of future export trends compiled from interviews with principals of log exporting companies in Grays Harbor will be presented. The final section will present the adopted log export forecast.

a. 1975 Port System Study. The 1975 Port System Study most probable forecast of log exports from Grays Harbor was at a constant level of 2,400,000 tons per year from 1980 to 2000. The forecast assumed practically all logs exported from the Pacific Northwest would be exported to Japan. The forecast was based on interviews with the major companies selling and buying export logs in Washington. The interviews established that substantial increases in export volumes in the future were not likely, and barring restrictive legislation, export volumes would remain fairly constant at the 1972 level. Therefore, the 1975 Port System Study considered the 1972 level of log exports to be the most probable level of log exports in 1980, 1990, and 2000 for Grays Harbor. The minimum level of log exports for Grays Harbor was projected at zero, since restrictive legislation was considered a definite possibility at the time the study was prepared. The maximum level of log exports in the future was not expected to outstrip the Japanese demand

for wood and could not exceed the surplus of harvest potential over local demand in the tributary area. Data published in the Japan Lumber Journal of 31 March 1973 suggested that the portion of Japanese demand for wood that would be met by imports would be 1.59 times the 1972 level in 1980, 1.65 times the 1972 level in 1990, and 1.49 times the 1972 level in 2000. If the Puget Sound, Pacific coast (i.e., Grays Harbor), and lower Columbia subregions were assumed to maintain their share of the Japanese market, then potential maximum exports for Grays Harbor could be estimated from the data in the Japan Lumber Journal as 3,800,000 tons in 1980, 4,000,000 tons in 1990, and 3,600,000 in 2000. The 1975 Port System Study log export forecast for Grays Harbor is summarized in table 12.

TABLE 12

PROJECTED LOG EXPORTS - 1975 PORT STUDY
(Thousands of Short Tons)

Year	Minimum	Most Probable	Maximum
1980	0	2,400	3,800
1990	0	2,400	4,000
2000	0	2,400	3,600

Source: Port System Study, March 1975, p. 4-22.

b. 1980 Port System Study. This updated version of the 1975 Port System Study projected a gradual increase in log exports over the long term (i.e., 1982-2000) but almost flat growth over the next decade. The flat growth from 1982 to 1990, including a decline in exports between 1982 and 1985, was based on the likelihood of further restrictions on log exports and stabilization of supply coupled with a short-term decline in Japanese demand. Currently, there are no restrictions on log exports from private or industrial forest lands. However, log exports from state lands in Alaska, California, Oregon, Idaho, and from national forests and Bureau of Land Management lands, are restricted. The objective of the Bonker Amendment to the Export Administration Act of 1979 is to embargo the export of redcedar logs produced in public forests in an attempt to insure an adequate timber supply for domestic cedar mills. The Bonker Amendment is expected to impact redcedar log exports by fall 1981 when export logs harvested from Washington State lands reach the export volumes provided for in the law.

Although the amendment narrowly focuses on a relatively small amount of western redcedar, greater implications are presented in its effect on overall United States foreign trade practices. Log export bans would primarily affect Japan. Additional log export restrictions contain the potential for significant impacts on the study area. Further log export

bans would be expected to result in a considerable loss in the utilization of harvested timber by eliminating valuable foreign markets. Log export restriction would also have a damaging effect on the study area's reputation as a reliable supplier to world markets, in addition to disrupting commercial relations with Japan, one of its major trading partners. If logs were no longer available from the Pacific Northwest, Japan would be forced to seek logs from alternative suppliers, probably the USSR, Canada, Chile, New Zealand, and various South Sea nations which already export logs to Japan. Some United States Government officials maintain the position that Japan will have to increase imports of processed forest products (lumber) in order to insure a continuing supply of softwood logs.

Over the long term, the 1980 Port System Study projected log exports to increase gradually due to continued Japanese demand for softwood logs, as an input to their domestic milling industry, and the continued price competitiveness of United States logs in foreign markets. The longer term forecast was based on the fact that as the Pacific Northwest lumber industry declines due to the shift of the United States timber industry to the southeastern United States, the Pacific Northwest timber industry will have to emphasize log exports to the Pacific Rim, with finished lumber exports complementing this supply. The 1980 Port System Study log export forecast for Grays Harbor is summarized in table 13.

TABLE 13

PROJECTED LOG EXPORTS - 1980 PORT STUDY
(Thousands of Short Tons)

Year	Low	Medium	High
1982	2,954	2,954	2,954
1985	2,728	2,728	2,728
1990	2,964	2,964	3,385
1995	3,421	3,563	4,167
2000	3,755	3,871	5,114

Source: Port System Study, 1980.

c. 1977 Forests Tributary Study. This study was mainly concerned with analyzing the wood potentially available for export in the Grays Harbor tributary area, but it also looked briefly at the export markets for logs, lumber, and woodchips. The study projected that Grays Harbor would continue to supply approximately 2.5 percent of the total Japanese demand for wood. In addition, the study predicted that the Port of Grays Harbor would benefit from growth in the South Korean wood market. The Korean demand is strongly tied to the Japanese demand in that most of the logs destined for Korea are processed into lumber in Korea and then exported to Japan. Log exports were assumed to remain more or less

constant at the 1976 level of approximately 2,735,000 short tons per year from 1980 through 2020, as shown in table 14.

TABLE 14

PROJECTED LOG EXPORTS - FORESTS TRIBUTARY STUDY
(Thousands of Short Tons)

Year	Volume
1980	2,735
1990	2,735
2000	2,735
2010	2,735
2020	2,735

Source: Forest Tributary To The Port of Grays Harbor, Greenacres Consulting Corp., 8 July 1977.

d. 1981 Forest Policy Project. The Forest Policy Project is a series of reports on various aspects of the Pacific Northwest timber industry. One of these reports, "Demand For Pacific Northwest Timber and Timber Products," prepared by Data Resources, Inc. (DRI), forecasted softwood log exports from the west coast, the Pacific Northwest region, and the western Washington subregion. Softwood log exports from the west coast more than doubled from an average annual volume of 1.15 billion board feet Scribner per year in 1961-1969 to 2.66 billion board feet per year in 1970-1979. The Washington customs district (which excludes Longview, Washington, and other ports on the Columbia River) accounted for 64 percent of the west coast total in the 1970's compared with 30 percent for the Oregon customs district, 4 percent for northern California, and 2 percent for Alaska. Japan was the destination for 92 percent of all west coast softwood logs exported during the 1970's. Most of the remaining 8 percent is exported to South Korea, where a significant volume is manufactured into lumber for sale to Japan.

The DRI model projected west coast softwood log exports to decline gradually over the forecast horizon. The critical assumption in this projection is a significant decline in Japanese softwood lumber demand, stemming from decreasing Japanese housing construction. The model assumes that west coast softwood log exports to other countries will increase modestly as Japanese demand softens. Beyond 2000, DRI assumes log exports will decline further, particularly in 2010 to 2020 when large volumes of Japanese softwood are expected to be available for harvest. The forecast of total west coast log exports is summarized in table 15. Projections beyond 2000 are trend projections which incorporate the assumption that more Japanese timber will be reaching harvestable age; they do not include a detailed examination of the demand outlook.

TABLE 15

SUMMARY OF WEST COAST SOFTWOOD LOG EXPORTS
(Billions of Board Feet, Scribner Scale, Per Year)

1961-1965	0.7
1966-1970	1.9
1971-1975	2.4
1976-1980	2.9
1981-1985	2.6
1986-1990	2.3
1991-2000	2.1
2001-2020	1.7

Source: Forest Policy Project, Study Module II-A, 1981, p. 1-89.

In supporting its forecast, DRI discussed its key forecast assumptions in detail. The highlights of the discussion are presented here because the DRI forecast was the only one that was supported by a detailed analysis of the end-use market in Japan. Housing starts in Japan averaged 1.54 million starts per year during the 1970's, compared with 0.87 million units per year in the 1960's. After peaking in 1973, however, starts have steadily declined as shown in table 16. Similarly, household formation declined after 1973 and was forecasted by DRI to decline nearly 40 percent from 0.77 million households per year in 1977-1979 to 0.47 million in 1998-2000. Growth in the adult household formation population over the next 20 years is a known quantity, since persons reaching maturity during this period have already been born.

TABLE 16

JAPANESE HOUSING STARTS
(Million of Units)

	Starts For Household Formation	Starts for Replacement and Vacancy Demand	Total Starts
1970	0.75	0.73	1.48
1971	0.95	0.52	1.46
1972	0.92	0.89	1.81
1973	1.00	0.91	1.91
1974	0.70	0.62	1.32
1975	0.90	0.45	1.36
1976	0.79	0.73	1.52
1977	0.78	0.72	1.51
1978	0.77	0.78	1.55
1979	0.76	0.73	1.49
1980			1.27
1981(estimated)			1.19

Source: Forest Policy Project, 1981.

DRI acknowledged uncertainty about future housing replacement and vacancy rates but assumed a rate of 0.60 million units per year in 1985 and thereafter. This assumption was based on several factors: (a) high vacancy rates (e.g., 7.6 percent in 1978 versus 4.0 percent in 1968) suggest an excess supply of housing; (b) replacement rates will slow over the next 20 years from the 2.0 percent per year rate of the 1970's versus 0.7 percent in the United States (i.e., the average age of the housing inventory in Japan is only 17.5 years); and (c) the housing mix is changing from wooden, single family units to steel and concrete multifamily units that last longer (i.e., 77 percent of all starts in 1965 were wooden versus 61 percent in 1979 versus 55 percent by year 2000). In short, DRI contends the housing boom in Japan is over and forecasts a decline in housing starts as shown in table 17. The 1981-1985 decline is mainly due to decline in household formation, and after 1985, due to this factor plus decreasing replacement rates.

TABLE 17

THE OUTLOOK FOR JAPANESE HOUSING
(Millions of Units Per Year)

	Household Formation	Replacement and Vacancy Demand	Total
1971-1975	0.89	0.68	1.57
1976-1980	0.77	0.69	1.46
1981-1985	0.70	0.67	1.38
1986-1990	0.63	0.60	1.23
1991-2000	0.53	0.60	1.13

Source: Forest Policy Project, 1981.

The following table summarizes other assumptions about the Japanese housing market used by DRI in its forecasts. Table 19 summarizes forecasted lumber consumption in Japan by major market. Softwood lumbers' share of total lumber consumption was forecasted to average about 73 percent from 1980 to 2000 as shown in table 20.

TABLE 18

SUMMARY OF DRI FORECAST ASSUMPTIONS

Parameter	Assumed Behavior
1. Wooden Versus Nonwooden Housing Starts	1. Wooden Share Decrease by 2000 a. 62 percent in 1980 versus 56 percent in 2000

TABLE 18 (con.)

Parameter	Assumed Behavior
2. Housing Size	2. Overall Increase by 2000
a. Wooden	a. Up 10 percent to 1,159 square feet
b. Nonwooden	b. Up 7 percent to 967 square feet
3. Lumber Usage in Housing	3. Substitute Cheaper Materials
a. Wooden	a. Use factor down 22 percent by 2000
b. Nonwooden	b. Use factor down 31 percent by 2000
4. Lumber Consumption in Housing (1 x 2 x 3)	4. Overall, 31 Percent Drop by 2000
a. Wooden	a. Down 33 percent by 2000
b. Nonwooden	b. Down 19 percent by 2000
5. Lumber Consumption - Nonhousing	5. Down 4 Percent by 2000
6. Lumber Consumption - Remodeling	6. Basically Flat 1980-2000
7. Lumber Consumption - Industrial	7. Up 13 Percent by 2000
	a. 23 percent market share in 1980 versus 30 percent in 2000

Source: Forest Policy Project, 1981.

TABLE 19

PROJECTED LUMBER CONSUMPTION IN JAPAN
(Millions of Cubic Meters Per Year)

Year	Wooden Housing	Nonwooden Housing	Nonresidential	Remodeling	Industrial	Total
1971-1975	15.15	2.60	6.56	7.58	9.92	41.81
1976-1980	15.93	2.56	5.65	5.30	8.84	38.29
1981-1985	14.96	2.59	5.81	4.98	9.20	37.55
1986-1990	12.60	2.27	5.56	5.01	9.25	34.70
1991-2000	10.70	2.08	5.40	5.34	10.03	33.55

Source: Forest Policy Project, 1981.

TABLE 20

LUMBER CONSUMPTION BY TYPE OF WOOD
(Millions of Cubic Meters Per Year)

Year	Total	Softwood	Softwood Share (percent)	Hardwood
1971-1975	41.81	30.84	74	10.97
1976-1980	38.29	28.25	74	10.04
1981-1985	37.55	27.78	74	9.77
1986-1990	34.70	25.33	73	9.37
1991-2000	33.55	24.00	72	9.55

Source: Forest Policy Project, 1981, p. 1-104.

The procedure DRI used in estimating future log imports in Japan was: (a) deduct softwood lumber imports from the total softwood lumber consumption shown in table 20, (b) convert the answer to softwood log requirements at Japan's sawmills (this step was not shown by DRI), and (c) subtract softwood logs available from domestic sources from this total to get log imports. Softwood lumber imports hovered in the vicinity of 3.0 million cubic meters between 1973 and 1977, rose to 3.4 million cubic meters in 1978, and then jumped almost 20 percent to 4.0 million cubic meters in 1979. DRI assumed future lumber imports in Japan would average 4.0 million cubic meters per year over the forecast period. However, DRI admitted that significant changes in public policy which encourage lumber exports to replace log exports could substantially alter this assumption. DRI also assumed the Japanese log harvest would continue at current levels through 2000. Projected log imports as determined by DRI are shown in table 21.

TABLE 21

JAPANESE SOFTWOOD LOG PRODUCTION AND IMPORTS
(Millions of Cubic Meters)

Year	Total Demand	Domestic Production	Total Imports	Imports From U.S.	Imports from U.S. Billion B.F. Scribner
1971-1975	38.40	20.1	18.3	9.3	2.2
1976-1980	35.70	17.3	18.4	10.5	2.7
1981-1985	34.20	17.2	17.0	10.2	2.5
1986-1990	30.90	17.2	13.7	8.1	2.1
1991-2000	28.90	17.2	11.7	7.0	1.8

Source: Forest Policy Project, 1981, p. 1-108

Over 90 percent of Japanese softwood log imports are purchased from the United States and the Soviet Union. A larger percentage of lumber is imported from Canada than from the U.S., but Canada supplies only about 2 percent of Japanese softwood sawlog demand due to the prohibitive log export policy that exists in British Columbia - individual permits must be obtained from the Provincial and Federal Governments. The share imported from the United States was relatively constant between 1970 and 1978, hovering between 48 percent and 55 percent. Table 22 depicts the quantities and market share of major softwood sawlog suppliers to Japan in 1978.

TABLE 22

JAPANESE SOFTWOOD SAWLOG IMPORTS BY COUNTRY OF ORIGIN, 1978

	Volume (Million Cubic Meters)	Percentage
United States	10.317	52.2
Soviet Union	7.919	40.0
New Zealand	0.777	3.9
Canada	0.312	1.6
Indonesia	0.238	1.2
Chile	0.093	0.5
Other	0.123	0.6
	19.779	100.0

Source: Forest Policy Project, 1981, p. 1-108.

A major shift in the United States market share occurred in 1979. DRI estimated 65 percent of Japanese softwood sawlog imports originated from the United States Most of this shift came at the expense of the Soviet Union. DRI believed the United States encroachment on Russian market share was more than a temporary aberration. Supply constraints have been hampering Russian exports and driving up prices. Siberian forest fires in the spring of 1978 and heavy cutting in recent years have reduced the available supply and quality of Russian timber. Japanese sawmillers are reportedly expressing dissatisfaction with Russian logs, citing the following reasons: (a) a higher percentage of poorer species is deteriorating the species mix; (b) on average, smaller diameter logs are being received at sawmills; and (c) decay and structural defects are becoming more common.

DRI assumed that the United States share of the Japanese softwood sawlog market will average 60 percent over the next 20 years, down from 1979, but significantly higher than the 54 percent average of 1975-1978. According to DRI, several factors will make it difficult for the United

States to maintain a 65 percent market share. First, the ongoing depletion of mature timber stands in the Pacific Northwest will result in smaller export logs in the future. As these logs become closer to the quality of sawlogs offered by the Soviet Union, the United States may lose their competitive edge in the Japanese market. Second, as the total volume of softwood sawlog imports in Japan decreases, a steady Russian market share would imply a reduced drain on the Russian timber resource. This may allow Russia to continue to effectively compete for market share. Finally, although New Zealands's and Chile's share of the Japanese market is still quite small, they have a large softwood resource base and are increasing their penetration of the Japanese timber market. DRI's forecast of United States log exports to Japan as presented in table 21 assumes the United States market share remains constant at 60 percent. Overall, DRI projected United States log exports to Japan would decline.

DRI also tested the sensitivity of its log export forecast to its most critical assumptions: (a) the number of housing starts and (b) the level of Japanese timber harvest. The base case forecast assumed 1.13 million housing starts per year in 1991-2000. For a sensitivity analysis, DRI assumed starts would continue at current levels of 1.5 million starts per year. The results for key variables are compared to the base case in table 23. If the annual average for housing starts is 1.50 million units in 1991-2000 (one-third higher than the 1.13 million starts per year in the base case), total lumber consumption would increase 12 percent or 4.1 million cubic meters per year (the percentage increase in softwood lumber consumption would be greater since most of the increment would be softwood). Such an increase would require an annual increase of 5.1 million cubic meters of softwood sawlog imports, nearly a 45 percent jump. If the United States maintains a 60-percent share of the Japanese softwood sawlog import market, this implies United States log exports would average 2.5 billion board feet (Scribner scale) per year in 1991-2000 (compared to 1.8 in the base case).

A significant increase in the Japanese softwood timber harvest would reduce Japanese demand for foreign timber (assuming no change in lumber consumption). DRI simulated the model of Japanese lumber and sawlog demand assuming the volume of domestic softwood logs delivered to sawmills increases 1 percent per year. This scenario implies 21.0 million cubic meters of softwood sawlogs will be supplied from domestic sources by 2000 (compared to 17.2 in the base case). The net result would be a 30 percent decrease in United States log exports to Japan in 1991-2000 (compared to the base case) - United States log exports to Japan would average only 1.3 billion board feet per year, as shown in table 23.

TABLE 23

IMPACTS OF ALTERNATIVE HOUSING AND HARVEST ASSUMPTIONS
(Annual Rates)

	1976-1980	1981-1985	1986-1990	1991-2000
Base Case				
Housing Starts (Millions)	1.46	1.38	1.21	1.13
Lumber Consumption (Million Cubic Meters)	38.3	37.5	34.7	33.6
Domestic Softwood Sawlog Harvest (Million Cubic Meters)	17.3	17.2	17.2	17.2
Total Softwood Sawlog Imports (Million Cubic Meters)	18.4	17.0	13.7	11.7
Log Imports from the U.S. (Billion Board Feet, Scribner)	2.7	2.5	2.1	1.8
Higher Housing				
Housing Starts	1.46	1.50	1.50	1.50
Lumber Consumption	38.3	39.1	38.3	37.7
Domestic Softwood Sawlog Harvest	17.3	17.2	17.2	17.2
Total Softwood Sawlog Imports	18.4	19.0	17.9	16.8
Log Imports from the U.S.	2.7	2.8	2.7	2.5
Higher Japanese Harvest				
Housing Starts	1.46	1.38	1.21	1.13
Lumber Consumption	38.3	37.5	34.7	33.5
Domestic Softwood Sawlog Harvest	17.3	17.7	18.6	20.1
Total Softwood Sawlog Imports	18.4	16.5	12.2	8.8
Log Imports from the U.S	2.7	2.4	1.8	1.3

Source: Forest Policy Project, 1981, p. 1-110.

The log export projections for the United States and the west coast essentially provide the log export outlook for the Pacific Northwest. Washington and Oregon consistently accounted for 95 percent of United States west coast log exports during the 1970's. The balance originated in northern California and Alaska. Over the forecast horizon, DRI assumed that 95 percent of west coast log exports will continue to be shipped from Washington and Oregon as summarized by decade in table 24. DRI further assumed that the western Washington subregion would account for 85 percent of the log export total. The decline in housing construction in Japan was assumed to decrease softwood lumber demand and, thus, decrease the demand for United States logs over the next two decades. Beyond 2000, significant increases in the timber yield from Japanese forests should lower Japan's dependency on imported logs according to DRI.

TABLE 24

LOG EXPORTS BY REGION
(Billion Board Feet, Scribner, per year)

	Washington and Oregon	Western Washington	Western Oregon
1961-1970	1.18	1.00	0.18
1971-1980	2.50	2.13	0.37
1981-1990	2.25	1.91	0.34
1991-2000	2.05	1.74	0.31
2001-2010	1.70	1.45	0.25
2011-2020	1.30	1.11	0.19

Source: Forest Policy Project, 1981, p. 3-37.

Both the DRI and Port System Study log export forecasts began with a forecast of United States exports and then disaggregated the national forecast, first to the west coast, then the Pacific Northwest region, then Washington State, and finally to a subregion. The biggest difference is that DRI assumed the west coast share of total United States log exports would remain at 100 percent through 2000, whereas the port study assumed (without explanation) the west coast share would drop from 96 percent in 1978 to 64 percent in 2000. Since neither study mentions the emergence of a new log exporting port(s) anywhere on the east coast, it seems more logical to assume all United States log exports to Pacific Rim countries will originate on the west coast. Both studies assumed Pacific Northwest log exports would average 95 percent of west coast exports, and that Washington State exports would average 85 percent of Pacific Northwest exports. Finally, Grays Harbor log exports were approximately 25 percent of Washington State log exports in 1979.

Assuming this 25 percent share remains constant over the forecast period, a forecast of Grays Harbor log exports can be derived from the DRI United States forecast as shown in table 25. The "high" and "low" forecasts correspond to the "higher housing" and "higher Japanese harvest" forecasts shown in table 23.

e. Regression Analysis. A fifth forecast of log exports from Grays Harbor was based on a least-squares regression analysis of historical log exports from 1961 through 1980 against time. The X-value or independent variable was the number of the year with 1961 being equal to 61. The dependent variable or Y-value was actual log exports measured in thousands of short tons. The curve best fitting the historical data (i.e., an R^2 value for Y of 0.844) was a logarithmic curve with the equation $Y = -44210.2275 + 10837.0159 \log x$. Forecasted values of log exports were determined by substituting the numbers 85, 90, 95, and 100 for X, as shown in table 26.

TABLE 25

PROJECTED LOG EXPORTS - 1981 FOREST POLICY PROJECT
(Billion Board Feet, Scribner)

Year	West Coast	PNW	Washington	Grays Harbor	Grays Harbor (1,000 short tons)
BASE CASE					
1976-1980	2.7	2.6	2.2	0.55	3,135
1981-1985	2.6	2.5	2.1	0.53	3,021
1986-1990	2.3	2.2	1.9	0.48	2,736
1991-2000	2.1	2.0	1.7	0.43	2,451
2001-2010	1.7	1.6	1.4	0.35	1,995
2011-2020	1.4	1.3	1.1	0.28	1,596
HIGH CASE					
1976-1980	2.7	2.6	2.2	0.55	3,135
1981-1985	2.8	2.7	2.3	0.58	3,306
1986-1990	2.7	2.6	2.2	0.55	3,135
1991-2000	2.5	2.4	2.0	0.50	2,850
LOW CASE					
1976-1980	2.7	2.6	2.2	0.55	3,135
1981-1985	2.4	2.3	2.0	0.50	2,850
1986-1990	1.8	1.7	1.5	0.38	2,166
1991-2000	1.3	1.2	1.0	0.25	1,425

NOTE: Grays Harbor = .25 (Wash.) = .85 (PNW) = .95 (west coast) x .0057 = short tons.

Source: Forest Policy Project, 1981.

TABLE 26

PROJECTED LOG EXPORTS USING REGRESSION ANALYSIS
(Thousands of Short Tons)

Year	Volume
1980	2,779
1985	3,935
1990	4,554
1995	5,140
2000	5,696

Historical log exports shown in table 7 illustrate the high level of variation in the export volumes, with Y-values ranging from 120,000 short tons to 3,585,000 short tons. A method of time series analysis that attempts to cancel out the effect of random variation is a smoothing technique using a moving average. That is, log exports of 1961, 1962, and 1963 would be averaged and used as the volume for 1962. The next point in the series (i.e., 1963) would be the average of volumes for 1962, 1963, and 1964. Thus the time series of moving averages would show a point for each year that would be the calculated average response for a 1-year interval below and above the given year. The net effect is to transform the original log export time series to a moving average series that is smoother and more likely to reveal the underlying trend or cycles in the pattern of exports over time. The 3-year moving averages are summarized in table 27. A second regression was done on these averages and again the logarithmic equation of $y = -43872.6200 + 10762.9404 \log x$ gave the "best fit" with an R^2 value for Y of 0.892. However, forecasted values of Y (i.e., log exports) were so close to those shown in table 26, that the new set of values was not tabulated as a separate forecast.

TABLE 27

THREE-YEAR MOVING AVERAGES OF LOG EXPORTS
(Thousands of Short Tons)

Year	Volume	Year	Volume	Year	Volume
1961	--	1968	2,036	1975	2,341
1962	199	1969	2,165	1976	2,391
1963	347	1970	2,027	1977	2,645
1964	631	1971	2,218	1978	2,929
1965	922	1972	2,411	1979	3,074
1966	1,296	1973	2,538	1980	--
1967	1,713	1974	2,335		

f. 1976 Feasibility Study. For comparison purposes only, the log export forecast used in the 1976 Grays Harbor Interim Feasibility Report on channel improvements is shown. That forecast was based on published studies and on data provided by log export companies in the Grays Harbor area. The forecast is summarized in table 28.

TABLE 28

PROJECTED LOG EXPORTS - 1976 FEASIBILITY STUDY
(Thousands of Short Tons)

Year	Volume
1984	2,400
2000	2,000
2030	2,000

4. Industry Opinion. Six timber companies and one trading company account for nearly all log exports in Grays Harbor. Principals with each of these firms were personnally interviewed in August 1981 to ascertain their insider viewpoints on future trends in log exports. Three things became apparent in these interviews. First, the 50-year forecast period used for project evaluation is meaningless to these companies because their version of a long-term forecast is usually limited to 1 or 2 years. Second, 1981 will probably be the worst financial year of record for the forest industry and, therefore, was not the optional time to be seeking industry opinion on future trends. The forest industry was hit with a poor overseas market in 1981 and simultaneously with a poor domestic housing market due to high interest rates. Finally, the persons interviewed were not market analysts who spent their time building elaborate econometric models to forecast future log exports. Their main concerns were running their own businesses and economic survival. However, they had observations and informed judgments about future log export trends based on reading trade journals and on business dealings with foreign timber buyers. Their viewpoints are presented here.

a. Japan Market. Based on the interviews, forest industry opinion can best be classified into comments on the strengths and on the weaknesses in overseas markets, particularly in Japan and China. Taking Japan first, one company owner commented on the costs of competition with Canadian lumber. He tallied up the approximate cost of shipping 1,000 board feet (Mbf) of Douglas fir logs to Japan as follows: \$400/Mbf (stumpage price) plus \$100/Mbf (ocean transportation) plus \$20/Mbf (insurance, exchange risk, financing) plus \$80 (exchange rate discounts) equals \$600/Mbf to the Japanese sawmill. Added to this is the cost of milling the logs into lumber. By comparison, Canadian lumber, at the time, had a landed price in Japan of \$340/Mbf. Not only can Canadian prices beat United States prices in Japan, they can beat Japanese prices in Japan. Major commodity price quotations listed in The

Japan Economic Journal for July 31, 1981, showed Canadian sawn hemlock priced wholesale at 40,000 yen per cubic meter versus Japanese redcedar board at 51,000 yen per cubic meter and and Japanese cypress at 125,000 yen per cubic meter.

There are several reasons for the lower Canadian lumber prices. Although Canadian mills and United States mills both buy trees from their governments, United States mills are required to competitively bid against one another at auctions, while Canadian companies are not. In 1978, Canadian mills paid $4.58 per cubic meter of stumpage, while mills in the Pacific Northwest paid $39.11 per cubic meter for comparable trees. Even without this government subsidy of roughly $34.53 per cubic meter, however, it is unlikely competitive bidding would push Canadian timber prices as high as United States prices. United States timber prices have also been bid up because United States Government restrictions on the allowable cut have created a scarcity of timber. In British Columbia, authorities have increased the allowable cut. Additional arguments against whether price equality could prevail are that the Canadian home market is much smaller than the United States home market and, therefore, exerts less domestic pressure on timber prices. Accordingly, Canadians have had to rely more on exports and have built their mills close to tidewater. Canadian mills are equipped to marshal huge amounts of lumber in dockside yards, load big ships, and get cheaper freight rates.

What keeps Grays Harbor timber companies in the picture are the relatively higher quality of their logs and their reliability as a source of supply for Japan. Grays Harbor companies can supply old-growth timber to Japan, compared with mostly second growth from Canada. Old growth trees do not have any limbs up to 100 feet and, therefore, fewer knots, and provide the clean lumber which is highly valued by the Japanese. In terms of supply, the finest timber growing lands in the North American continent, (i.e., of yield per acre) are located on the Olympic Peninsula and other areas tributary to the Port of Grays Harbor. The analysis in section 1 of this exhibit further underscores the fact that the wood potentially available for export far exceeds most of the forecasts of export demand. The Japanese have historically paid a premium for supply reliability. Based on the quality and stability of the region's logs, industry opinion was that Grays Harbor would continue to supply a significant segment of Japan's demand.

b. Log Versus Lumber Exports. The next area of discussion was what these individuals foresaw in terms of future Japanese demand for Northwest logs. The consensus of those who offered an opinion was that there probably would not be a significant increase in log exports. They forecasted the most likely scenario to be a gradual substitution of lumber for logs, with the total combined tonnage of the two being pretty much the same as in 1980. Lack of growth of log exports was attributed to lack of growth in Japan's housing market. Rising land prices, rising construction material cost, and high interest rates were seen as major demand limiting factors. Other recent trends in Japan are increased

floor space per dwelling, a concurrent decrease in the share of wooden housing in total dwelling starts every year, a fall in wood consumption per dwelling, and a shift from singly built wooden houses to condominiums. Accordingly, the Japanese market has experienced a quantitative decrease in housing as well as a change in the demand structure (i.e., a structural decline).

The substitution of lumber for logs was seen as being due to a combination of factors: economic, sociological, and political. The Japanese expect a substantial and permanent reduction in (Japanese) sawmilling capacity and a continuing increase in the proportion of their market supplied by imported lumber. The amount of domestic lumber produced has been dropping since 1967. During the 1960's, foreign timber to a large extent crowded local wood out of the processing and distribution network. Since 1963, the number of sawmills using Japanese timber exclusively decreased from 23,000 to 7,000, while those processing foreign logs increased from 433 to 3,400. Now, however, many of the mills relying on foreign logs have gone out of business as a result of a depressed housing market in Japan and their economic inability to buy United States log, saw them into lumber, and compete with imported Canadian lumber. A second major factor behind the decline in sawmill capacity is a shortage of labor in the mountain villages where timber is grown. Young people have migrated from rural areas to high technology jobs in the cities, causing an increase in the average age (i.e., the average age of a logger is 45 years) and in the percentage of women in the mountain communities. Forestry work is heavy labor and involves a number of occupational hazards. The wage scale is low, and the work is highly seasonal and sporadic. With employment conditions so poor, the reduction of the sawmill labor force has also contributed to mill closure. Neither of these factors was taken into consideration in the DRI log export forecast. DRI assumed that the Japanese timber harvest after the year 2000, if significant, would lower Japan's demand for imported logs. This is self-evident, but DRI never questioned who would be doing the harvesting and who would be running the sawmills. A third and political factor was considered to be the United States-Japan Lumber Trade Promotion Committee, an industry-to-industry group formed specifically to increase the proportion of United States sawn lumber exports to log exports in the log-lumber export mix. The politics of the committee are basically that the Japanese will always have some demand for logs to produce sizes of lumber the United States or Canada cannot or will not produce. The Japanese also realize the State of Washington is the most dependable supplier of the high quality species of lo that they prefer. Accordingly, the price to the Japanese of maintaining free trade in logs is greater importation of lumber. The politics basically are the same at the national level where Federal laws prohibiting log exports entirely have been a subject of controvery for at least the past 6 years. The decline in Japanese sawmill capacity, plus political pressure from the United States, will both contribute to growth in lumber exports to Japan, and a gradual substitution of lumber for logs.

c. China Market. The final area of discussion was the potential of the China market. Log exports to China from Grays Harbor totaled 367,000 short tons during the first 8 months of 1981. Annual tonnages from all Washington ports to China were estimated by a trading company at approximately 1,710,000 short tons per year. A trading company was recently formed to procure logs for shipment to China. Those timber companies, with an eye toward the China market, regard it as being in its infancy now but as having a potential that could dwarf anything seen so far in Japan. A series of articles in various issues of the 1981 Forest Industries and Journal of Forestry magazines provided the following background material on China's forest industry.

The Chinese population of nearly 1 billion creates a tremendous demand for wood for cooking and heating fuel, furniture, millwork, paper products, and nonstructural building applications such as interior partitions. Wood is not a building material in China and no prospects exist for changing the concrete and brick construction methods used for all residential, commercial, agricultural, and industrial buildings of any size. In general, China is rich in tree species (i.e., about 3,000 species versus 679 for the United States) but poor in forest resources. In the distant past, China was very rich in forest resources. By 1949, however, continuous exploitation, extensive conversion of land to agriculture, and repeated destruction by wars brought forested acreage to a little over 8 percent of total land area.

By 1979, China's forested lands covered 301 million acres, or 9.5 billion cubic meters of wood volume, equivalent to 12.7 percent of the nation's land area. An estimated 637 million acres (27 percent of the total land area) are suitable for forest growth, and it is the Government's goal to have 20 percent of the land area forested by the year 2000. This means planting 175 million acres in 20 years. However, reforestation (replanting forests) and afforestation (converting bare land into forests) efforts have been hampered by poor survival rates, limited research, competition for land with the agriculture industry, and a shortage of well-trained scientists, genticists, and professional foresters. Forest are alse very unevenly distributed, with the greatest concentration in the remote border areas. The highest volumes are in northeastern China near the Siberian border. The next largest volumes are in the southwestern mountains where the first railroad reached only recently. Accordingly, much of the resource is in lightly populated, virtually inaccessible areas. Emphasis is being placed on greenbelt and erosion control plantings as well as commercial timber.

Although the limited forest resources in China are being augmented by log imports from Southeast Asian countries and recently the United States, the adequacy of timber supply is a continuing concern. As China's government strives to upgrade living conditions for its urban dwellers, the rapid pace of building will provide a continued strong demand for furniture and millwork, relative to the country's limited forest resources. The lumber mills and manufacturing plants are labor intensive, reflecting national employment policy as well as a late start

toward mechanization, although this labor intensiveness leads to economic inefficiencies. As the plants modernize, output will accelerate at a rate that will create serious timber supply problems unless reforestation is accelerated as well.

Right now, China is short on capital and long on manpower. The government is tryping to solve the first problem by expanding exports of manufactured products. The second problem can be mitigated with an expansion of production facilities that will put more people to work. With wood products high on the list of potential export items, one can expect future competition in world markets from China, both for the sale of manufactured products and for the purchase of logs.

There was no consensus among Grays Hrabor shippers on the logistics of log exports to China. One log exporter said vessels carrying logs to China are presently limited in size to about 27,000 deadweight tons (DWT) due to port depths of 9.6 meters (31.5 feet) at Shanghai. However, another shipper said this was not a serious obstacle as larger vessels can be (and currently are) offloaded in deeper water in the bays and the logs are brought to shore in log rafts. This adds to the unloading cost, but the added cost may be offset by the use of a larger vessel.

The one area where agreement was unanimous was that no forecast of log exports from Grays Harbor could be considered complete without including the log export market in China, which some felt was big enough to more than offset the projected decline in Japanese demand.

5. Adopted Log Export Forecast. Based on a thorough analysis and evaluation of the alternative log export forecasts, their underlying assumptions, and industry opinion, the adopted forecast of log exports to Japan was the DRI base case forecast from table 24. This forecast was more representative of projected declines in housing starts, household formation, and overall timber demand in Japan than the other forecasts. One problem with the DRI forecast was that is did not include demand by China, which already is and will continue to be an important log export market. Accordingly, the DRI forecast was augmented by a forecast of log exports to China, the latter being well within the range of current exports to China. The adopted forecast is summarized in table 29.

TABLE 29

ADOPTED LOG EXPORT FORECAST
(Thousands of Short Tons)

Year	Japan	China	Total
1980	2,625	175	2,800
1990	2,400	200	2,600
2000	2,000	300	2,300
2010	1,600	400	2,000
2040	1,600	400	2,000

Average Annual Equivalent: 1990-2010 : 2,400
2010-2040 : 2,000
1990-2040 : 2,300

SECTION 3

FORECAST OF FUTURE LUMBER EXPORTS

1. Historical Lumber Exports. The total volume of lumber shipped from the Port of Grays Harbor during the period 1970 through 1980 is summarized in table 30. The data shows that total lumber shipments more than doubled between 1970 and 1980, with one very high volume year in 1979.

TABLE 30

HISTORICAL LUMBER SHIPMENTS - GRAYS HARBOR
(Million Board Feet)

Year	Total	Domestic1/	Export2/	Export (short tons)3/
1970	30.9	30.8	0.1	346
1971	40.8	39.8	1.0	2,412
1972	43.5	41.6	1.9	5,213
1973	52.6	34.6	18.0	46,560
1974	71.0	31.1	39.9	101,869
1975	78.4	26.0	52.4	135,402
1976	74.4	31.1	43.3	111,877
1977	77.8	32.8	45.0	116,193
1978	106.6	47.9	58.7	151,744
1979	130.5	40.8	89.7	231,754
1980	84.2	23.3	60.9	157,445

Source: Port of Grays Harbor Annual Reports, 1970 through 1980.

1/Domestic markets are mainly in California. Shipments are made by barge.
2/Export markets are the Orient, Mediterranean, and Europe. Orient's share is usually 90 percent or more.
3/Million board feet x .0025833 = short tons.

This sharp increase in lumber shipments has been the result of the development of export markets, since domestic shipments have remained relatively steady, averaging 34.5 million board feet per year over the 10-year period.

Although lumber exports have grown rapidly at Grays Harbor, they still represent a relatively small proportion of total exports. In 1979, lumber exports reached a 10-year high, but still were only 6 percent of total exports from Grays Harbor. A similar picture holds for other

areas. Census data shows that in 1979 lumber exports, as a percent of total major commodity exports, were 0.8 percent for the United States, 2.4 percent for the Pacific coast, 3.2 percent for the Pacific Northwest, and 2.4 percent for the State of Washington. Lumber exports are far less concentrated in the Pacific Northwest than are log exports. In 1979, 93 percent of all U.S. log exports were shipped from Pacific Northwest ports. By comparison, the Pacific Northwest accounted for a much lower 51 percent of total United States lumber exports; the balance being shipped from Oregon and California ports. Grays Harbor accounted for 5 percent of all United States lumber exports in 1979.

2. Market Analysis. The market forces determining future lumber exports are similar to those that determine future log exports. Future trends in Japanese domestic timber consumption are expected to comprise the driving forces behind future foreign export demand for forest products. Historically, Japan has imported large volumes of logs rather than finished lumber from the United States. Thousands of Japanese sawmills process logs into hundreds of sizes that are unique to Japanese construction methods. Importing logs rather than lumber is a form of protectionism for these sawmills. Additionally, exported logs (i.e., Douglas fir) have been priced consistently lower (i.e., 13-20 percent lower) than the Japanese cedar they compete with in the domestic structural lumber market in Japan. Demand for housing is the primary driving force of Japanese demand for softwood logs and finished lumber. Specifically, Japanese timber demand is a function of new household formation and new housing starts, both of which are forecasted to decline as the Japanese population matures.

The continuing shift of the United States timber industry to the southeast United States has progressively pushed the domestic market for Pacific Northwest lumber west of the Rocky Mountains. Therefore, additional supplies will be available for Pacific Rim trade. In addition, producers in British Columbia can ship lumber to the United States east coast at less cost than Pacific Northwest mills because Canada can use less costly foreign flag vessels, whereas United States producers are required by the Jones Act to use United States ships. This difference costs Pacific Northwest producers $20 per 1,000 board feet more to ship to the east coast than Candian producers. The impact of this is evident in that west coast shares of the United States northeast lumber market have declined from 30 percent in 1964 to less than 5 percent in 1978. This trend is not likely to change due to recent shifts by American mills to the southeast. Therefore, an increasing share of export lumber from the Pacific coast will be available for Pacific Rim trade, allowing for a continuation of historic shares of export cargo. Major shifts are not anticipated in exports in that the Pacific Northwest as a percent of Pacific coast is expected to remain relatively constant.

3. Alternative Lumber Export Forecasts. As is the case with log exports, several projections of lumber exports from Grays Harbor are available. Each of these forecasts will be reviewed briefly in terms of their underlying assumptions, where possible, and resultant forecasts.

a. 1975 Port System Study. The conclusion of the 1975 Port System Study was that long-term prospects for lumber exports depended heavily on log export policies. Lumber exports were projected to increase between 1980 and 2000, but the increase would be much greater if a major curtailment of log exports to Japan were legislated. Table 31 shows the minimum, most probable, and maximum forecasts for Grays Harbor. The minimum forecast assumes no curtailment in log exports, whereas the maximum forecast assumes a major curtailment. The lumber market in Europe was characterized as a major one for softwood lumber, but also as one being principally supplied by the USSR and Canada through the year 2000.

TABLE 31

PROJECTED LUMBER EXPORTS - 1975 PORT SYSTEM STUDY
(Thousands of Short Tons)

Year	Minimum	Most Probable	Maximum
1980	140	260	380
1990	160	300	430
2000	180	330	480

Source: Port System Study, 1975, page 4-22.

b. 1980 Port System Study. According to this study, the key to future increased levels of United States lumber exports to Japan is based on the transition of traditional Japanese residential construction methods to acceptance of western-style housing using standard United States lumber sizes. Industry officials maintain that the acceptance of western-style housing, utilizing standard United States lumber sizes such as 2x4's and 2x6's is expected to provide expanded opportunities to sell more United States finished lumber to Japan. Starts of platform frame houses, which utilize standard American lumber sizes, rose from 168 units constructed in 1974 to 6,050 units during 1978, representing a 144.97 percent annual growth rate, as shown in table 32.

Continued prospects for increased levels of platform frame houses appear optimistic according to the Port study. The Japanese Platform Frame Construction Association estimates that at least 40,000 2x4 frame houses are expected to be built annually, beginning as soon as 1985. However, the construction costs of platform frame houses have not decreased as much as had previously been expected, relative to the cost of traditional Japanese residential construction methods. Future levels of United States finished lumber exports to Japan are also expected to be enhanced by change in Japanese lumber standards and the establishment of plywood performance testing standards. A major milestone for marketing United States lumber products to Japan involved the adjustment of Japanese lumber standards to more closely match United States grading rules.

TABLE 32

STARTS OF PLATFORM FRAME HOUSING IN JAPAN
1974 to 1978

Year	Platform Frame Starts
1974	168
1975	2,572
1976	5,117
1977	5,163
1978	6,050
Annual Percent Growth 1974-78	144.97

Source: Japan Platform Frame Construction Association; Port System Study, 1980, page 4-46.

The revised Japanese lumber standards, which went into effect on 9 July 1978, apply to dimension lumber such as 2x4's and 2x6's typically used in platform frame construction methods. Both Japanese and United States standards for light framing, structural light framing, and joints and planks are now essentially identical.

The study's overall outlook was that lumber exports would continue increasing at or slightly higher than present growth rates, depending on trade agreements between the United States and Japan. Using a weighted average share method whereby projected United States lumber exports were allocated by percentage share to progressively smalled geographical areas, the study derived projected lumber exports for Grays Harbor as shown in table 33.

TABLE 33

PROJECTED LUMBER EXPORTS - 1980 PORT SYSTEM STUDY
(Thousands of Short Tons)

Year	Volume
1982	105
1985	122
1990	150
1995	189
2000	238

NOTE: The generalized share method used in the study to derive these volumes is Grays Harbor = 15 percent (Washington) = 46 percent (Pacific Northwest) = 92 percent (Pacific Coast) = 55 percent (United States).

Source: Port System Study, 1980.

The low volume of 105,000 tons in 1982 was caused by a decrease in Grays Harbor's share of Washington State's lumber exports from 25 percent in 1979 to 15 percent in 1982 and thereafter. The reduced export volume for Grays Harbor was shown as being redistributed to lower Columbia-Washington ports such as Longview. In other words, lumber exports from Washington State were forecasted to increse by a factor of 2.46 between 1979 and 2000, by a factor of 2.02 in Puget Sound ports, a factor of 4.99 for lower Columbia ports, but only by a factor of 1.51 for Grays Harbor. The study gave no explanation for the timing or magnitude of the decrease and redistribution. However, the study did project that 16 new forest products berths would be required by the year 2000 to accommodate forecasted log and lumber exports, eight of which were said to be needed by the Port of Grays Harbor. The study concluded the port did not have sufficient acreage or shoreline to accommodate the new facilities. This may have led to the shift of market share, but the study did not so indicate. No navigation channel improvements are planned for lower Columbia ports by 1982 that would justify any greater comparative shipping advantage for lower Columbia ports at the expense of Grays Harbor than that which existed in 1979. If the Grays Harbor share remained at 25 percent of Washington State, the volumes shown in table 33 would be shown as increasing from 156,000 tons in 1982 to 388,000 tons in 2000.

c. 1977 Forest Tributary Study. This study did not provide a separate lumber export forecast but concluded that lumber exports would increase substantially over their 1976 level of 112,000 short tons. This contrasts with log and ship exports which were forecasted to remain "more or less constant" at their 1976 levels. The forecasts shown in the study were a minimum and maximum forecast for logs, lumber, and chips combined. By deducting the 1976 volumes of logs and chips, the residual volume approximated lumber exports. Accordingly, the forecast of lumber exports is likely to resemble that shown in table 34.

TABLE 34

PROJECTED LUMBER EXPORTS - 1977 FOREST TRIBUTARY STUDY
(Thousands of Short Tons)

Year	Volume
1980	153
1990	169
2000	183
2010	183
2020	215

Source: Forest Tributary Study, 1977.

d. <u>1981 Forest Policy Project</u>. The DRI forecasts in this study focused on the end-use demand in Japan for Pacific Northwest softwood log and lumber exports. The study projected that Japanese preference for wooden dwellings would remain strong in the face of unfavorable economics (i.e., exhorbitant land prices), mainly due to traditional preference for wooden homes. The study pointed out that a great deal of wooden house building still occurs in urbanized areas in defiance of the Japanese National Building Regulations: this being an example of the Japanese fondness for wooden structures. The study also elaborated on the inability of the 2x4 home to penetrate the Japanese market as a reflection of Japanese attitudes. The discussion merits full quotation since this pessimistic outlook is directly opposite that of the 1980 Port System Study.

> "The popular frame dwelling of North America has failed to catch on in Japan. Introduced by the Japanese Construction Ministry in 1974 as a means of cutting rapidly inflating construction costs, 2x4 homes have captured less than 0.5% of market share, falling far short of even the most conservative predictions.
>
> "The primary reason that the 2x4 homes were expected to produce substantial savings is the reduction labor costs. One estimate suggests that construction of standardized 2x4 dwellings could reduce man-hours by 40% compared to other traditional method of building Japanese homes.
>
> "But the price of a 2x4 home exceeds that of the traditional home and can be afforded only by the more wealthy Japanese. A poor distribution system for pre-cut lumber has kept prices for this material at high levels. Distribution centers are virtually nonexistent due to the small volume of pre-cut lumber handled; thus, special orders must be placed to purchase required supplies.
>
> "Another major obstacle to the success of the 2x4 home has been the Japanese fondness for the traditional wooden home. Even in cases where people purchase frame dwellings, it is not uncommon for them to artificially produce the old-style interior by utilizing decorative beams and panels. Japanese emphasize appearance and attempt to maximize the amount of exposed wood.
>
> "The idea of instituting the standard frame dwelling on a widespread basis in Japan is still very much alive, however. The Japan Wood Frame Association is working with the British Columbian government to set up demonstration houses in nine Japanese cities (this is the same method which created a market for prefab housing). Lack of consumer knowledge is considered to be one reason that 2x4 homes have met little success. Additionally, the Japanese government has revised several building codes to promote the construction of standardized housing." (page I-III)

The DRI analysis does not rule out the eventual transition of traditional Japanese construction to western-style housing using standard United States lumber sizes, but the lumber export forecast reflects DRI's skepticism. The DRI forecast assumes United States lumber exports to Japan will not increase much beyond their 1979 level of 4.0 million cubic meters. Lumber exports hovered in the vicinity of 3.0 million cubic meters between 1973 and 1977, rose to 3.4 million cubic meters in 1978, and jumped 20 percent to 4.0 million cubic meters in 1979. The 1979 increase was attributed to a combination of strong lumber demand, speculative inventory accumulation, and serious log shortages. However, DRI assumed United States lumber exports would remain high and average 4.0 million cubic meters per year from 1980 through 2000. Four million cubic meters equals 2,189,470 short tons using the following conversion formula: Cubic meters x 35.3145 = cubic feet x 6 = board feet x .0025833 equals short tons. This tonnage was proportioned down to Grays Harbor based on the market shares that existed in 1979, and assumes these market shares will remain constant throughout the forecast period. The only exception was the Pacific coast share of United States lumber exports. Based on actual 1979 census data, and as shown in the footnote to table 33, the Pacific coast accounted for 55 percent of total United State lumber exports to all countries in 1979. The remaining 45 percent was probably Atlantic coast shipments to European countries. However, if total United States shipments refers only to those sent to Japan, as is the case in the DRI forecast, then the Pacific coast share is closer to 100 percent because almost all United States lumber exports to Japan originate somewhere on the Pacific coast or Alaska. Accordingly, a figure of 95 percent (i.e., the same as DRI used for logs exports) was used to estimate the Pacific coast share of United States lumber exports to Japan. Projected lumber exports derived from the DRI study are shown in table 35.

TABLE 35

PROJECTED LUMBER EXPORTS - 1981 FOREST POLICY PROJECT
(Thousands of Short Tons)

Year	United States	Pacific Coast	Pacific Northwest	Washington	Grays Harbor
1980	2,189	2,080	1,976	889	222
1990	2,189	2,080	1,976	889	222
2000	2,189	2,080	1,976	889	222

NOTE: Forecasted United States lumber exports of 2,189,470 short tons per year were allocated based on actual 1979 tonnage as follows: Grays Harbor = .25 (Washington) = .45 (Pacific Northwest) = .95 (Pacific Coast) = .95 (U.S.) = 222,000 short tons per year.

Source: Derived from Forest Policy Project, 1981, page 1-107.

e. Regression Analysis. A fifth forecast of lumber exports was based on a least-squares regression analysis of historical lumber exports from 1970 through 1980, which are shown in table 30. The curve best fitting the historical data (i.e., an R^2 value for the dependent or Y-variable of 0.853) was a logarithmic curve with the equation $y = 6651160.7119 + 1563175.1311 \log x$. Forecasted log exports based on this equation are shown in table 36.

TABLE 36

PROJECTED LUMBER EXPORTS USING REGRESSION ANALYSIS
(Thousands of Short Tons)

Year	Volume
1980	157
1985	293
1990	383
1995	467
2000	547

f. 1976 Feasibility Study. For comparison purposes only, the lumber export forecast used in the 1976 Grays Harbor Interim Feasibility Report on channel improvements is shown in table 37. That forecast was based on published studies and on data provided by log export companies in the Grays Harbor area. The 1976 forecast is shown in table 37.

TABLE 37

PROJECTED LUMBER EXPORTS - 1976 FEASIBILITY STUDY
(Thousands of Short Tons)

Year	Volume
1984	300
2000	330
2034	330

4. Adopted Lumber Export Forecast. Only the 1980 Port System Study forecast explicitly considered lumber demand in countries other than Japan. Examples of these countries are China, Korea, Taiwan, Malaysia, Australia, Peru, and Atlantic Europe and Mediterranean countries. However, the 1980 port forecast appears too low during the early part of the forecast. Projected lumber exports from Grays Harbor of 105,000 short tons in 1982 were exceeded in 6 of the 7 years from 1974 to 1980, and the projected 1985 volume of 122,000 short tons was exceeded in 4 of the 7 years. These low forecasts may be due to the census data used as a base for the Port study's forecast. The 1979 volume of 158,000 tons,

used to make the forecast was considerably lower than the volume shown in Port of Grays Harbor records of 232,000 short tons. Alternatively, the Port System Study's log export forecast for Grays Harbor shows a very high growth in spite of their assumption that housing demand in Japan will decline. The DRI forecast, as derived at 222,000 short tons, is too high in the early years based on historical volumes. On the other hand, both forecasts appear too low around the year 2000. The port forecast is low because it did not allow for a change in export mix of lumber for logs, and the DRI forecast is low because it did not include demand by countries other than Japan. Accordingly, the adopted forecast was based on actual 1980 volumes, rising by 1990 to a volume between DRI and the port forecast, and reaching a peak by the year 2010 in excess of both forecasts. The adopted forecast is shown in table 38.

Over the 1990-2040 forecast period, the adopted lumber export forecast expressed as an average annual equivalent (at 7-5/8 percent interest) equals 256,000 short tons per year. Similarly, the adopted log export forecast expressed as an average annual equivalent is 2,300,000 short tons per year. The total volume of log and lumber exports is thus

TABLE 38

ADOPTED LUMBER EXPORT FORECAST
(Thousands of Short Tons)

Year	Volume
1980	157
1990	200
2000	250
2010	310
2040	310

Average Annual Equivalent:	1990-2010 :	240
	2010-2040 :	310
	1990-2040 :	256

forecasted to average 2,556,000 short tons per year. Over the 1970-1980 period, combined log and lumber exports from Grays Harbor averaged 2,638,000 short tons per year. Accordingly, the adopted forecasts reflect industry opinion that total log and lumber export volume in the future will probably not be significantly different from the current combined volume and also that there will be a change in export mix in favor of more lumber and fewer logs.

SECTION 4

FORECAST OF FUTURE WOODCHIP EXPORTS

1. Historical Woodchip Exports. The total volume of chips shipped from the Grays Harbor during the period 1968 through 1980 is summarized in table 39. The historical data show that chip exports have declined steadily since reaching a peak in 1970. The only chip loading facility

TABLE 39

HISTORICAL WOODCHIP EXPORTS - GRAYS HARBOR
(Short Tons)

Year	Volume	Year	Volume
1968	234,605	1975	160,138
1969	379,742	1976	208,420
1970	404,000	1977	204,246
1971	308,000	1978	89,837
1972	316,000	1979	173,027
1973	289,000	1980	166,149
1974	220,000		

Source: Port of Grays Harbor Annual Report, 1970-1980.

in the harbor is the Weyerhaeuser facility upstream of the Chehalis River bridge. There is a possibility that a second facility could be built near the mouth of the Hoquiam River by a consortium of smaller timber companies. Woodchips, a byproduct when trees are milled into lumber, are used to make pulp which is used to make paper. The forecasted increase in lumber exports indicates that the supply of chips will grow considerably over the future. The remaining variable is the overseas demand for chips, which thus far has been limited exclusively to Japan. The following forecasts present alternative pictures of what this future demand will look like.

2. Alternative Woodchip Export Forecasts.

a. 1975 Port System Study. The conclusion of the 1975 Port System Study was that woodchip exports from Grays Harbor would remain constant at about 400,000 tons per year over the 1980-200 forecast period. Woodchip exports started at Grays Harbor in 1968 and at other ports in the Puget Sound and lower Columbia region in 1967. The study projected that the Japanese demand for chips from the Pacific Northwest would increase substantially by the year 2000, but that most of the increase would be supplied by Puget Sound (e.g., Tacoma) and lower Columbia (e.g., Longview) ports. The study further projected that some roundwood would have

to be chipped since the existing mills in the Grays Harbor region would not have the capacity to produce the total volume of residuals required by the domestic pulp and board industry and also to supply the export market. Roundwood supplies (i.e., harvest potentials) were seen as sufficient to meet the maximum demand placed on them for domestic consumption, log exports, and chip exports. The 1975 port study's minimum, most probable, and maximum woodchips forecasts for Grays Harbor are shown in table 40.

TABLE 40

PROJECTED WOODCHIP EXPORTS - 1975 PORT SYSTEM STUDY
(Thousands of Short Tons)

Year	Minimum	Most Probable	Maximum
1980	300	400	1,000
1990	300	400	1,200
2000	200	400	1,400

Source: Port System Study, 1975, Vol. II, Part 3, p. 4-22.

b. 1980 Port System Study. According to this updated port study, Japanese demand for paper and paper products is expected to increase between 2.5 and 3.0 percent annually between 1980 and 1985 and by a similar rate from 1985 and 1990. This forecast is based on the Japan Paper Associations's estimate that domestic pulpmill capacity will increase by about 12 percent between 1979 and 1983 in response to an increased level of Japanese demand for paper and paper products. As a result, woodchip and pulpwood exports are expected to increase over the next decade. The port study projected woodchip exports from Washington State would more than quadruple by the year 2000 and that two new chip facilities would be required. There are presently five woodchip terminals in the state: two in Tacoma, three in Longview, and one in Grays Harbor. The first of the new chip terminals was assumed to be required in 1995 and the second in 2000, both located in the lower Columbia region. Japanese demand for chips grew 4.93 percent per year from 1975 to 1978, averaging approximately 11.8 million short tons per year. Washington State ports provided 13 percent of the Japanese demand for woodchips in 1975 and 1976 but only 11 percent in 1977 and 9 percent in 1978. Increased woodchip exports originating from the Oregon coast contributed to this decline. Over the same 4-year period, the relative market shares of chip exports among Washington ports averaged the following: Tacoma - 42 percent, Grays Harbor - 10 percent, and Longview - 48 perent. By the year 2000, the Port study forecasted the relative shares at: Tacoma - 30 percent, Grays Harbor - 9 percent, and Longview - 61 percent. With Grays Harbor staying about the same, the increase in Longview's share was forecast to come at the expense of Tacoma. The forecast of woodchip exports from Grays Harbor is shown in table 41.

TABLE 41

PROJECTED WOODCHIP EXPORTS - 1980 PORT SYSTEM STUDY
(Thousands of Short Tons)

Year	Volume
1980	166
1985	292
1990	395
1995	510
2000	598

Source: Port System Study, 1980.

c. 1977 Forest Tributary Study. This study did not provide a separate woodchip export forecast but concluded that woodchip exports would remain more or less constant at their 1976 level of 208,000 short tons, as shown in table 42.

TABLE 42

PROJECTED WOODCHIP EXPORTS - 1977 FOREST TRIBUTARY STUDY
(Thousands of Short Tons)

Year	Volume
1980	208
1990	208
2000	208

Source: Forest Tributary Study, 1977.

d. 1981 Forest Policy Project. According to the DRI forecast prepared for this study, export demand for woodchips will remain very strong in the 1980's. This will stem from the development of a paper production industry in Pacific Rim countries. Scandanavian and continental European pulp producers will also be supplementing their domestic wood supplies with imported woodchips. However, the South will be in the better position to supply this market, whereas West coast exporters will concentrate on Pacific Rim demand. Overall, DRI projected softwood chips would be a "prized commodity in the international raw materials market." Countervailing the offshore demand for chips, DRI projected considerable pressure on United States chip producers to supply the domestic market, especially on the West coast. Accordingly, DRI forecasted only a modest increase in West coast woodchip exports from 310 million cubic feet in 1979 to 315 million cubic feet in 1990, and to 387 million cubic feet by 2020. No separate woodchip forecast was provided

for an area smaller than the West coast, so the West coast growth rates were simply applied to the Grays Harbor chip tonnage of 173,000 tons in 1979 to derive a Grays Harbor forecast for this study.

e. Industry Opinion. The only woodchip facility in Grays Harbor is the Weyerhaeuser facility upstream of the Chehalis River Bridge. Weyerhaeuser projected its woodchip exports to remain at the 1980 level of 166,000 short tons per year through the year 2000. The company did not make a projection beyond the year 2000.

TABLE 43

PROJECTED WOODCHIP EXPORTS - 1981 FOREST POLICY PROJECT
(Thousands of Short Tons)

Year	West Coast	Grays Harbor
1979	310	173
1990	315	176
2010	360	203
2020	390	218
2040	390	218

f. Regression Analysis. A fifth forecast of woodchip exports was based on a least-squares regression analysis of historical exports from 1970 through 1980. A nonlinear regression estimate of the form log exports = 46747.3936 x e exp(-0.1025 x year) represented the best fit of the historical data ($R^2 = 0.769$). Because of the strong influence of the decline in woodchip exports since 1970, however, the forecast based on the regression analysis simply continued this downward trend, ultimately approaching zero by the year 2040. There is no realistic scenario under which chip exports from Grays Harbor would drop to zero, so the regression-based forecast was not used.

g. 1976 Feasibility Study. For comparison purposes only, the woodchip export forecast used in the 1976 Grays Harbor Feasibility Report on channel improvements is shown in table 37. This forecast was based on the forecast proviced by the Weyerhaeuser Company.

3. Adopted Woodchip Export Forecast. The forecasts of woodchip exports in both the 1980 Port System Study and the 1981 Forest Policy Project (i.e, DRI) are predicted on a growing export market and are shown as increasing over time. The difference in the magnitude of their respective growth rates is that the DRI forecast was made subject to the constraint of satisfying West coast demand first and exporting what was left over. This constraint implicitly assumed United States buyers would be willing to pay a higher price for the chips than Japanese

TABLE 44

PROJECTED WOODCHIP EXPORTS - 1976 FEASIBILITY STUDY
(Thousands of Short Tons)

Year	Volume
1984	250
2000	200
2034	200

buyers. The port study forecast focused exclusively on the export market and simply allocated market shares to woodchip ports in Puget Sound, Grays Harbor, and the lower Columbia. The DRI analysis of the demand market included both foreign and domestic markets, and was, therefore, more comprehensive than the 1980 Port forecast. Also, the DRI forecast, as derived and applied to the Port of Grays Harbor, showed tonnage volumes that were closer to the volumes in the Weyerhaeuser forecasts provided in 1976 and 1980. Because of horizontal clearance restrictions imposed on Grays Harbor woodchip vessels by the Chehalis River bridge, woodchip vessel size will permanently be limited to about 2[illegible],000 DWT if the bridge is not widened. Even with bridge widening, however, vessel size would only increase to 35,000 DWT because of limitations on vessel length imposed by the channel configuration above the bridge. It makes sense that the volumes of woodchips exported will not change dramatically in absolute terms because there are no transportation economies to support such a change unless a second export facility is built downstream of the bridge. Accordingly, future changes in export volumes were not seen as being of a large magnitude, at this time. The adopted forecast was based on the DRI forecast to the extent that there would be long-term growth in the woodchip market. The adopted forecast was also based on the two Weyerhaeuser forecasts (1976 and 1981) to the extent that export volume would remain constant to the year 2000 (i.e. as per the 1981 Weyerhaeuser forecast) and would average about 200,000 tons per year after the year 2000 (as per the 1976 Weyerhaeuser forecast). The adopted forecast is shown in table 45.

TABLE 45

ADOPTED WOODCHIP EXPORT FORECAST
(Thousands of Short Tons)

Year	Volume
1980	166
1990	166
2000	166
2010	200
2040	200

Average Annual Equivalents: 1990-2010 : 171
2010-2040 : 200
1990-2040 : 177

EXHIBIT 2

FUTURE FLEET ANALYSIS

GRAYS HARBOR, WASHINGTON

TABLE OF CONTENTS

TABLE OF CONTENTS (con.)

TABLES

FIGURES

TABLE OF CONTENTS (con.)

SECTION I

TIMBER CARRIER ANALYSIS

1. Introduction. The huge growth in the volume of cargo shipped in bulk (i.e. full shiploads of a single commodity) led to the rapid expansion of the world bulk carrier fleet, which began in the mid-1950's and gradually gathered momentum during the 1960's. The bulk carrier can be defined as an oceangoing, single deck vessel designed to carry the more simple, homogeneous dry bulk cargoes with maximum economic efficiency. Bulk carriers include dry bulk carriers (e.g., alumina, cement), liquid bulk carriers (e.g., asphalt, molasses tankers), combination carriers (e.g., bulk/oil, ore/bulk/oil), and neobulk carriers (e.g., cars, forest products). It is virtually impossible to load conventional bulk carriers to full capacity with forest products and this has acted as a disincentive for their employment in these trades and led to the consequent development of specialized forest products carriers. Forest products carriers are ships specifically designed to carry one or more forest products in bulk and consist of the following vessels: (a) timber carriers, (b) woodchip carriers, and (c) pulp carriers. This section deals with timber carriers and pulp carriers.

2. World Timber Carrier Fleet in 1975. The Bulk Carrier Register, which is published annually, is a record of all bulk carriers and combined carriers in the world having a deadweight of 10,000 long tons (i.e., a long ton equals 2,240 pounds) and above. In addition to providing a compilation of vessel characteristics, the Register usually contains a table titled "Special Types of Bulk Carriers." This table lists the name and deadweight tons (DWT) of all vessels in the world fleet that are of a particular type (e.g., ore carriers, cement carriers, vehicle carriers, etc.) The 1975 Register listed all timber carriers (i.e., log and lumber vessels) in the world fleet at that time. Many vessels have been built and added to the fleet since 1975, but the listing was the only one available to date that provided a broad picture of the world fleet. The size distribution of the timber carriers listed in 1975 and other vessel characteristics are summarized in table 1. The world timber carrier fleet in 1975 consisted of 142 vessels and was dominated by relatively small vessels, with 43 percent of the fleet in the 15,000-19,999 DWT category and 63 percent of the fleet under 25,000 DWT. The oldest ships in the fleet are also the smallest, those under 15,000 DWT, while the newest ships are the more midsized vessels in the 25,000-29,999 DWT range. The average of all vessel sizes, weighted by the proportion of vessels (i.e., percentage of total) in each size group, was 21,453 DWT. Only four of the 142 vessels in the 1975 world fleet exceeded 35,000 DWT. Length, beam, and design draft values for the 1975 timber carrier fleet are plotted against DWT in figure 1.

3. Grays Harbor Timber Carrier Fleet

Introduction. A profile of the timber carrier fleet presently calling at Grays Harbor was determined from monthly reports on shipping activity compiled by (a) the Port of Grays Harbor, (b) longshoring companies in Grays Harbor, and (c) the Grays Harbor pilots. The reports covered the 10 months of January through October, 1980, and were the most up-to-date records available at the time this fleet analysis was prepared. This 10-month sample provided accurate baseline data for existing vessel movements in Grays Harbor under the without-project condition. The following information was determined for the log, lumber, and woodchip vessels that called at Grays Harbor in the first 10 months of 1980: (a) vessel name; (b) loading terminal; (c) deadweight tonnage; (d) net registered tonnage; (e) type of cargo (i.e., logs, lumber, chips) and amount of cargo loaded; (f) dates and times of vessel arrival, vessel departure, and when longshore gangs finished loading the vessel; (g) arrival and departure drafts; and (h) ports of call or destination after departure. Length, beam, year built, and design draft data for the vessels in the sample was taken from the Record of the American Bureau of Shipping, 1980.

4. Log Vessels

a. Log Vessel Fleet in 1980. From January through October 1980, 160 vessels called at Grays Harbor to pick up export shipments of logs. Vessels loading lumber or combinations of logs and lumber will be discussed separately later on. Table 2 summarizes pertinent characteristics for 77 of the 160 vessels. The 77 vessels are those for which published data on vessel dimensions, especially deadweight tonnage, was readily available in shipping registers and did not have to be estimated. The averages shown along the bottom of the table were weighted in proportion to the number of ships (i.e., percentage of total) in each deadweight category. Looking at average design draft versus average departure or sail draft, the two values are very close in terms of overall averages (i.e., 31.8 feet vs. 31.9 feet) and across each of the DWT categories, except for the 30,000-34,999 DWT group. Port records show four of the five vessels in this particular category left the port partially loaded, thereby accounting for the 6.3-foot difference between the 36.1-foot design draft and 29.8-foot sail draft. In some DWT categories, the table shows sail draft exceeding design draft, although only by a matter of inches. This will happen occasionally, but, in most instances, design draft and sail draft can be assumed to be equal for a fully loaded log vessel. In terms of the most popular size vessel, the second and third columns of the table show 123 log vessels or 77 percent of the fleet fell in the 15,000-24,999 DWT size range.

b. Log Vessel Fleet in 1973. One of the main reasons for proposing widening and deepening improvements to an existing navigation channel is to accommodate larger, deeper draft, and more cost efficient vessels. To determine if log vessels calling at Grays Harbor are actually getting

bigger, an historical trend was analyzed by looking at average log vessel size in 1980 (see table 2) compared with average log vessel size in 1973 (see table 3). A total of 187 vessels carrying logs only departed from Grays Harbor in 1973. The size distribution and other vessel characteristics for 139 of these 187 vessels, a 74 percent sample, are shown in table 3. The average size vessel in the 1973 log vessel fleet was 17,893 DWT. This compares with 22,061 DWT for the 1980. Over the 7 years from 1973 to 1980, average log vessel size in Grays Harbor increased 4,168 DWT, or 23 percent. This is an increase of 595 DWT per year. Over the same 7-year period, average vessel length increased 6 percent, or 31.95 feet, from a fleet average of 495.75 feet in 1973 to a fleet average of 527.7 feet in 1980. Average vessel width increased 7 percent, or 5.46 feet, from 73.34 feet in 1973 to 78.8 feet in 1980. Design draft increased 4 percent, or 1.2 feet, from 30.6 feet in 1973 to 31.8 feet in 1980. Average sail draft for the log vessel fleet increased 8 percent, or 2.4 feet, from 29.5 feet in 1973 (not shown in table 3) to 31.9 feet in 1980. Although all vessel dimensions have not increased at the same rate over the past 7 years, this historical analysis clearly demonstrates that the trend in log vessels calling at Grays Harbor has been to larger, longer, wider, and deeper draft vessels. These changes are summarized in table 4.

c. Detailed Analysis of 1980 Fleet. A more detailed analysis of the drafts of all 160 log vessels that called at Grays Harbor from January through October 1980 is shown in parts A, B, C, and D of table 5. Arrival drafts and sail drafts vary according to four conditions: (a) vessels arrive empty, sail full; (b) arrive empty, sail part full; (c) arrive part full, sail full; and (d) arrive part full, sail part full. Only two of the 160 log vessels in the analysis arrived part full and sailed part full. The monthly shipping reports compiled by the Port usually designated if a vessel had an intermediate port of call after leaving Grays Harbor (i.e., vessel was partially loaded outbound), or if the vessel stopped at another port before arriving at Grays Harbor (i.e., partially loaded inbound). In other cases, partially loaded vessels could be detected based on inbound or outbound draft, or on a comparison of cargo load versus vessel size. Unless otherwise specified in the Port records, vessels were assumed to be partially loaded inbound if their arrival draft was 23 feet or more, and partially loaded outbound if their departure draft was 28 feet or less. Secondly, the simple ratio of cargo load to DWT (i.e., short tons of logs divided by DWT in long tons) would generally range from 0.80 to over 1.0 for a fully loaded vessel. If a ratio was significantly out of this range, say around 0.4 to 0.6, the vessel was generally assumed to have taken on only a partial load of logs at Grays Harbor.

As shown in part A of the table, average arrival draft for all 160 log vessels was 21.18 feet (i.e., 21 feet 2 inches), and average sail draft was 30.54 feet (i.e., 30 feet 6 inches). The minimum sail draft recorded for any log vessel in 1980 was 19 feet 7 inches, and maximum sail draft was 34 feet 9 inches. With few exceptions, channel and bar

dimensions in Grays Harbor effectively limit timber carrier drafts to 34 feet. For some sail draft categories, the average sail draft is shown to exceed the average design draft. This was caused by a quirk in the data. Sometimes design draft data was unavailable in the shipping registers, so where sail draft might be averaged over 43 vessels, design draft may have been averaged over, say, only 30 of the 43 vessels. If the 30 vessels turned out to be on the lower end of a size range of deadweight tonnages, the value for average design draft would likewise be on the low side. As discussed previously, sail draft generally does not exceed design draft.

d. Fully Loaded Vessels. Of the 160 log vessels that called at Grays Harbor in the first 10 months of 1980, 76 vessels, or 47 percent of the fleet, arrived empty and departed fully loaded. Detailed draft data for these fully loaded vessels is shown in part B of table 5. These vessels had an average inbound draft of 20 feet and an average outbound draft of 32.29 feet. Seventy-seven percent of the vessels in this group had sail drafts between 30 feet and 33 feet 11 inches. Average cargo load of 18,478 short tons divided by average DWT of 21,039 long tons was 0.88, indicative of a fully loaded log vessel. Alternatively, the average cargo load was 78 percent of deadweight capacity measured in short tons (i.e., 21,039 long tons times 1.12 = 23,546 short tons and 18,478/ 23,564 = 78 percent.) There were no vessels with sail drafts of 28 feet or less in the fully loaded classification.

e. Partially Loaded Vessels. As shown in part C of table 5, 38 of the 160 log vessels, or 24 percent of the fleet, arrived at Grays Harbor partially loaded with logs from a previous port of call. The arrival draft of these vessels averaged 25.73 feet (i.e., 25 feet 9 inches). The average sail draft of 32.08 feet is practically the same as for the fully loaded vessels shown in part B. This indicates that almost all log vessels arriving partially loaded at Grays Harbor topped off their cargoes and departed fully loaded. The only exceptions were the two vessels in the below 28-foot category. These two vessels arrived part full and left part full, so they were counted twice, once in part C of the table and once again in part D. Average cargo load for the partially loaded inbound vessels is, as expected, less than the 78 percent of short ton deadweight capacity established in part B. These vessels loaded at 38 percent of short ton deadweight capacity (i.e., 8,902/21,134 times 1.12 = .38). Alternatively, the ratio of cargo load to DWT is 8,902/21,134 tons or 0.42, thereby indicating a partially loaded vessel. The 48 log vessels that were partially loaded outbound had a fleet average sail draft of 27.15 feet (i.e., 27 feet 2 inches) and were loaded at 35 percent of short ton deadweight capacity, as shown in part D of table 5. In summary, the sail draft category of 28 feet or less contained a total of 32 vessels. All 32 left Grays Harbor partially loaded. At the other end of the spectrum, a total of 18 vessels had sail drafts of 34 feet or more, and all 18 sailed fully loaded from Grays Harbor.

5. Lumber Vessels

a. Introduction. Lumber and log vessels both belong to the fleet of forest products carriers designated as timber carriers. However, the distinction between log and lumber vessels is ambiguous because lumber vessels on occasion also carry logs or pulp with their lumber cargo, and log vessels sometimes carry combined cargoes of logs and lumber. This is not a frequent occurrence, maybe 3 or 4 times a year in Grays Harbor, but it does indicate the vessels are not permanently and exclusively committed to one cargo. Accordingly, data on vessel size, length, beam, and draft for the historical world timber fleet, as well as for the future world timber fleet, is applicable to both log vessels and lumber vessels.

b. Lumber Vessel Fleet in 1980. From January through October 1980, 13 lumber vessels called at Grays Harbor. These vessels ranged in size from the 16,600 DWT USA Maru to the 44,000 DWT Hoegh Minerva and Hoegh Miranda. The "Hoegh class," or "M class," vessels are the largest timber carriers calling at Grays Harbor. These vessels make several ports of call before sailing for Japan. On one occasion, for example, the Hoegh Miranda made stops at Longview and Grays Harbor, Washington, and then at Vancouver and Nanaimo, British Columbia. Only one of the 13 lumber vessels arrived empty and sailed fully loaded. The remaining 12 were either partially loaded inbound, outbound, or both. Table 6 summarizes pertinent characteristics of the lumber vessels. The average fleet size of 29,793 DWT is much larger than the 22,061 DWT for log vessels, due in part to the influence of the Hoegh class vessels on the fleet average. The partial loading of lumber vessels is reflected in two places in the table, the relationship between (a) DWT and cargo load and (b) between design draft and sail draft. Average cargo load of 9,552 tons is only 29 percent of short ton deadweight capacity, whereas it could be as high as 80 percent if the vessels were fully loaded. Average sail draft of 29 feet is far below the average design draft of almost 34 feet. Sail draft would be close to or equal to design draft if the vessels were fully loaded. Inbound drafts of the 13 lumber vessels averaged 24 feet 5 inches due to inboumd drafts as high as 32 feet for partially loaded vessels. If all the vessels had arrived empty, this average inbound draft for the 13 vessels would have been 2 or 3 feet less. Multiple ports of call (i.e., three or four stops) are characteristic of the existing lumber vessel fleet, especially the Hoegh class vessels. Buyers in Japan who may buy a certain quantity, dimension, and species of lumber from one port and another quantity, dimension, and species or a completely different product at an alternate port. Vessels carrying the lumber or mix of forest products thus have to make several stops to pick up all the cargo. When the vessels arrive in Japan, they also may make several stops, unloading their cargo in the reverse order in which it was loaded. Suppose the first port of call in Japan is for linerboard. Therefore, the linerboard must be the last cargo put on the ship. This ship would have to bypass Grays Harbor because Grays Harbor cannot service vessels at deeper draft stages.

With its present channel dimensions, Grays Harbor can accommodate vessels making multiport calls only on the first or second port of call when the vessels' drafts are below their maximum. This means the cargo picked up at Grays Harbor must be the last unloaded in Japan. Grays Harbor is thus frequently bypassed by the larger vessels because the channel limits the flexibility of the vessels, as dictated by the port rotation pattern when the vessel reaches Japan. However, according to the Grays Harbor pilots, a deeper channel at Grays Harbor would reduce the frequency of partial loading and the number of ports of call, and many of the vessels now leaving Grays Harbor partially loaded would leave fully loaded. The vessels calling at Grays Harbor have been in service an average of only 5.5 years, which places them among the newest vessels calling at Grays Harbor.

6. Pulp Vessels. A total of 12,269 short tons of pulp were exported from Grays Harbor in 1980 on five ships. Two of the shipments were combined with lumber on a lumber vessel. One of the shipments was loaded on a vessel that on a previous call at Grays Harbor carried a full load of logs. Another pulp shipment was put on a vessel that previously carried a partial load of lumber out of Grays Harbor. That is, four of the five pulp shipments were put on timber carriers rather than vessels specifically designated as pulp carriers. Accordingly, the fleet analysis for log and lumber vessels was assumed to be appropriate for pulp vessels as well, and a separate fleet analysis for pulp carriers was not considered necessary.

SECTION II

FORECAST OF FUTURE TIMBER CARRIER FLEET

1. Related Studies

Introduction. Several studies have been conducted over the past 6 years on characteristics and future trends in timber carriers. The various studies have focused either on regional or national trends in timber carrier size and, accordingly, provided a good cross section of expert opinion on the future fleet. These studies will be reviewed and analyzed in this section and used as a basis for forecasting trends in vessel characteristics of the future timber carrier fleet calling at Grays Harbor.

2. 1975 Port System Study. The first regional study to specifically analyze existing and future fleet characteristics of forest products carriers was the Port System Study completed in March 1975. This study forecasted waterborne commerce and changes in shipping and cargo handling technologies from 1980 to the year 2000 for the subregions identified in figure 2. According to the study, a specific type of ship has evolved over the past 15 years to handle the relatively large cargo units of lumber, logs, pulp, and newsprint. This is the so-called open-hatch ship, which has extremely large hatch openings over squared-off cargo holds, enabling the large, heavy cargo units to be lowered directly into any place in the hold. Ships intended for the forest products trades are frequently fitted out to carry either lumber, logs, pulp, or newsprint. Ships fitted for carrying lumber and logs are usually specially designated as timber carriers because of the unique arrangement of the cargo handling gear. Softwood lumber and logs require a large volumetric capacity, so timber carriers rely on considerable deck stowage of cargo to achieve sufficient volume. To facilitate this, the cargo gear is mounted high to swing clear of a full deck load. Because of high center of gravity of the cargo, it is important that timber carriers have good stability. Thus, the dimensions of timber carriers are generally typical of bulk carriers, except timber carriers tend to be wider beamed. Sometimes extra water ballast capacity is provided.

Results of 1975 Port System Study. The 1975 Port System Study forecasted a gradual increase in the average and maximum size timber carrier, as shown in figure 3 and table 7. For 1980, the average vessel size was forecasted to be 22,000 DWT. Log vessels calling at Grays Harbor in 1980 averaged 21,593 DWT (see table 5), which is very close to the 5-year-old forecast. The average vessel size for 1990 was forecasted to be 28,000 DWT, an increase of 6,000 DWT or 600 DWT per year over 1980. By comparison, log vessels calling at Grays Harbor increased in size 595 DWT per year between 1973 and 1980. The Port System Study also forecasted maximum vessel size at about 40,000 DWT in 1980, according to figure 3. This is a little low due to the 44,000 DWT Hoegh class vessels that started calling at Pacific Northwest ports in 1979. By the

year 2000, average vessel size was forecasted to reach 35,000 DWT and maximum vessel size about 60,000 DWT. The 1975 study also forecasted the average number of vessel trips per year in three subregions of the Pacific Northwest, based on the most probable forecast of trade in logs divided by the average cargo load per vessel, as shown in table 7. The decrease in the number of vessel trips was the result of increasing vessel size. Log exports were forecasted at a constant level of 2,400,000 tons per year from 1980 to 2000. Given a constant volume of exports, larger vessel sizes meant more cargo per vessel and, hence, fewer vessel trips per year. The study concluded that although some lumber or plywood was likely to be diverted to containerships, timber carriers, with their current technology, would still be the primary means of lumber shipment from waterside mills to waterside distribution points.

3. 1980 Port System Study. The 1975 Port System Study was updated in 1980, but the discussion of future trends in timber carrier size was very limited. The 1980 version basically reiterated a fleet forecast made by the U.S. Maritime Administration (MarAd) in January 1979 and did not shed any new light on the future fleet analysis. The 1979 MarAd forecast is the second of two MarAd forecasts that will be discussed next.

4. TBS-MarAd Merchant Fleet Forecast. The second study that looked at future vessel sizes was the Merchant Fleet Forecast of Vessels in U.S.-Foreign Trade, 1980-2000, prepared for the Maritime Administration by the Massachusetts consulting firm of Temple, Barker and Sloane (TBS) in May 1978. The merchant fleet forecast, made in increments of 5 years from 1980 to 2000, was prepared using computerized fleet forecast programs developed over a 3-year period. The forecast was made for the number, size, and design characteristics of nine groups of vessels (see table 8) serving U.S.-foreign commerce on the four coasts of the U.S.: Atlantic, Gulf, Pacific, and Great Lakes. Of particular interest is the Pacific coast forecast of neobulk carriers, which includes timber carriers. The fleet forecast, which was used in conjunction with a cargo forecast prepared by MarAd, was only for foreign and U.S. flag vessels engaged in U.S.-foreign trade, so it was not a forecast of total world shipbuilding activity. To the extent that vessels trade foreign-to-foreign, the forecast understated the number of individual vessels required.

a. Results of TBS Fleet Forecast. The cargo forecast prepared by MarAd projected a 13 percent increase in U.S.-foreign trade between 1975 and the year 2000, but the number of vessels in the world fleet (including U.S. flag vessels) required to serve this trade was forecasted by TBS to grow by only 379 vessels, or about 10 percent, between 1975 and 2000. That is, TBS forecasted a trend to larger, more efficient vessels in every ship type. The projected increase in deadweight tons per vessel for the world fleet from 1975 to 2000 averaged 71 percent. For neobulk carriers, average vessel size was forecasted to increase 22 percent

or about 240 DWT per year from 21,705 DWT in 1980 to 26,514 DWT in the year 2000. Vessels were also forecasted to become more efficient, with an average annual increase in productivity for all vessels (i.e., long tons of cargo per DWT) of 1.1 percent per year between 1975 and the year 2000 (i.e., 31.6 percent total growth). Average annual capacity per DWT for neobulk carriers in particular was forecast to increase 21 percent or 0.96 percent per year between 1980 and 2000. That portion of the TBS merchant fleet forecast pertaining to Pacific Coast neobulk carriers is summarized in table 9. The vessel characteristics shown in table 9 are averages of all vessels in each size group and do not represent any specific vessel.

b. Comparison of TBS and Port System Forecasts. The TBS and Port System forecasts were made for different study areas and different vessel types. The TBS forecast was for the entire West Coast and for a group of vessels called neobulk carriers, of which timber carriers were a part. The Port System forecast defined a Pacific coast subregion which included only the Ports of Grays Harbor and Willapa Harbor, and the vessel forecast was specifically for timber carriers. Acknowledging these differences, there is one similarity in the trends of both forecasts. Both studies projected an increase in average vessel size over the 1980 to 2000 time period, although at different rates. The TBS forecast said average DWT per neobulk carrier would increase from 21,705 DWT in 1980 to 22,751 DWT in 1990, and finally to 26,514 DWT in the year 2000. This represents an average linear increase of 4,809 DWT over 20 years, or 240 DWT/year. The Port System forecast projected timber carriers to increase from 22,000 DWT in 1980 to 28,000 DWT in 1990, and finally to 35,000 DWT in the year 2000. This is an average linear increase of 7,000 DWT over 20 years, or 350 DWT/year. That is, the Port System forecast is projecting a faster rate of increase in average vessel size between 1980 and the year 2000. In the period 1975-1980, the Port System Study forecast has been accurate.

5. RSI-MarAd Dry-Bulk Carrier Forecast. The third study to forecast vessel sizes was the seven-volume effort called Development of a Standardized U.S. Flag Dry-Bulk Carrier. This study was also prepared for MarAd by the New York consulting firm of M. Rosenblatt and Son, Inc. (RSI), in January 1979. The purpose of the RSI study was to develop the design factors and requirements needed for long-range competitiveness of ships found to be the most suitable for serving the dry-bulk trades of the United States. The study found that three ship sizes (i.e., 15,000-25,000 DWT, 35,000-40,000 DWT, and 60,000-70,000 DWT) were appropriate for standardized designs. The study found that the importance of small sized bulk carriers between 15,000 and 25,000 DWT would be diminished but not eliminated by the growing demand for larger bulk carriers involved in the coal, iron, ore, and grain trades. The study forecasted small bulk carriers would carry one-third of all U.S. seaborne commerce through the year 2000. A standard design for a small sized timber carrier was determined to be 24,108 DWT. Medium sized bulk carriers between 35,000 and 45,000 DWT were projected to carry one-fourth of all U.S. waterborne trade through the year 2000. Water depths

in a number of ports around the world, especially in many U.S. ports, restrict the draft at which a laden vessel can sail to less than 40 feet. The study concluded that this restriction would ensure demand for medium sized carriers through the turn of the century. A standardized design for a medium sized bulk carrier would be sized to suit existing port facilities worldwide, as well as those that are expected to develop in the near future. This indicates the ship should be less than 625 feet long, less than 92 feet wide, and have a design draft of not more than 40 feet. A standard design for a medium sized timber carrier was determined to be 38,860 DWT. The large size bulk carriers were forecasted to be the "Panamax" size vessels, 60,000 to 70,000 DWT, less than 775 feet long, maximum beam of 106 feet (i.e., the Panama Canal limit), and design draft of 45 feet.

a. Standard Sized Timber Carriers. Determining standard sized timber carriers for shipping forest products to and from the U.S. in future years was complicated by the diversity of products (i.e., logs, lumber, chips, pulp, paper, plywood) and by stowage and handling problems. Compared with other dry-bulk commodities, forest products have high stowage factors. For example, the cubic capacity required to stow 1 ton of lumber is likely to be at least 1-1/2 times that required for a ton of wheat. Other high volume-to-weight products offer more problems. Woodchips may require more than twice as much hold capacity as the equivalent tonnage of grain. Consequently, ordinary bulk carriers are often unable to operate at full deadweight cargo loading when they are employed in the forest products trade. Cargo handling times for most forest products are high (chips being a notable exception) and, consequently, time spent in port loading and discharging is longer than for other dry-bulk trades. Chips are the only forest product for which gravity-assisted handling can be employed (allowing loading and discharging at approximately 385 short tons/hour), since other commodities are either too large or too fragile or consist of products of random sizes. Improvements are being made by shipping products in a form that makes them more amenable to rapid handling (for example, baled pulp), but opportunities for large-scale handling time reductions are limited.

b. Major Forest Products Ports. According to the RSI study, North Pacific ports dominate trade in forest products, although pulp and paper and, to a lesser extent, sawn lumber and board are also shipped through the Gulf and South Atlantic ports to foreign markets. The study considered the following ports as North Pacific ports in making its vessel fleet forecast: Oregon - Coos Bay, Portland, and Astoria; Washington - Longview, Grays Harbor, Port Angeles, Seattle, Tacoma, and Everett; Alaska - Ketchikan, Wrangell, Sitka, and Anchorage. Using 1976 waterborne commerce statistics, the RSI study showed these North Pacific ports exported 76 percent of total U.S. forest products seaborne exports, with Grays Harbor fourth in volume behind Coos Bay, Tacoma, and Longview.

c. Forecast of U.S. Forest Products Trade. The RSI forecast, like the Port System and TBS forecasts, also projected that ships in the forest products trade will gradually continue to get larger. Quoting from the report:

"Specialised bulk carriers are most prevalent on West Coast North America-Japan routes, which employ the majority of the existing larger bulk timber and chip carriers. Vessels of 20-35,000 DWT dominate the long-haul West Coast North American trades, mainly shipping lumber products to the Far East, with the larger vessels in the forest products fleet (35-50,000 DWT) supplementing these. Port limitations at some US North Pacific ports limit shipments in vessels of over 35,000 DWT. Elsewhere, Coos Bay can handle vessels of 40-45,000 DWT and Tacoma is open to "Panamax"-sized vessels. However, advantages gained by using large vessels at these ports have to be set against the widespread practice of multi-port loading for forest products.

"The trading pattern is unlikely to be radically altered over the next 25 years, although shipments are expected to continue to gravitate towards 20-35,000 DWT ships, with the lumber-dominated North Pacific trades favouring an increase in the use of medium-sized vessels (i.e., 35,000-45,000 DWT). It has been forecast that no vessels of over 50,000 DWT will be used in the US forest products trade" (appendix C, page 166).

The only unexplained discrepancy in the above quotation is the last sentence that no forest products vessels will exceed 50,000 DWT. The 1980 Bulk Carrier Register lists four woodchip vessels over 50,000 DWT which are already a part of the world fleet, the biggest being the 56,986 DWT Eden Maru. These four vessels were built between 1971 and 1976, so they will still be in service in the 1990's, assuming a service life of 20 years as per the RSI study. Even appendix C of the RSI study (page 34) lists three lumber carriers and four woodchip carriers in excess of 50,000 DWT. The shift toward larger forest products vessels at North Pacific ports and the forecasted growth in total U.S. forest products trade are shown in the last two columns of table 10. Total U.S. trade in forest products (exports and imports) is forecast to grow 2.6 percent per year average annual from 105.8 one thousand million (mmm) in 1980 to 177.3 mmm by the year 2000. Terminology and abbreviations are defined at the bottom of table 10. Vessels in the 20-34,999 DWT category were projected to carry 79 percent of total North Pacific forest products commerce (i.e., 47.6 mmm/60.2 mmm = 79 percent), with vessels in the 35-49,999 DWT category picking up 15 percent of the total. By the year 2000, vessels in the 35-49,999 DWT group were forecast to carry 25 percent of total North Pacific trade (i.e., 22.9 mmm 91.6mmm = 25 percent), while the 20-34,999 DWT group drops slightly in relative share to 75 percent of the total. It should also

be noted that North Pacific ports are the only ports in the United States designated by the RSI study to show any increase in forest products vessel size from the 30-34,999 DWT group to the 35-49,999 DWT group. Prototypes of vessels in the medium size 35-49,999 DWT group are currently calling at North Pacific ports. The Hoegh "M" class ships, which call at Grays Harbor several times per year, are 44,000 DWT, 660 feet long, 101 feet wide, and have fully loaded drafts of 37 feet.

d. Comparison of Port System, TBS, and RSI Forecasts. The Port System and TBS forecasts were more explicit in their forecasts of future timber carrier size than was the RSI forecast. The TBS forecast said average vessel size would be 21,705 DWT in 1980 and 26,514 DWT in the year 2000. The Port System Study forecast said average timber carrier size would increase from 22,000 DWT in 1980 to 35,000 DWT in the year 2000. The RSI study did not forecast average vessel sizes but rather designated very broad vessel size groups (i.e., 20-34,999 DWT and 35-49,999 DWT) and allocated a share of total forest products commerce to each group. Each vessel size group spans a range of 15,000 to 20,000 DWT, which is too broad to meaningfully determine a representative average size vessel. All three studies forecasted an increase in the average size of timber carriers between 1980 and the year 2000, with the majority of vessel sizes and cargo carried focusing in the 20,000-35,000 DWT range. This is the size range frequently referred to as "handy-sized bulk carriers." The remainder of the forest products cargo will be carried on vessels larger than 35,000 DWT.

6. Projected Timber Carrier Fleet for Grays Harbor. Historical data presented in section 1 on the composition of the timber carrier fleet calling at Grays Harbor showed the average size of timber carriers had increased 23 percent between 1973 and 1980. Three studies that looked at future trends in timber carrier size were reviewed in this section and all three indicated the historical growth in vessel size that was occurring in Grays Harbor could be expected to continue over the next 20 years. The projected timber carrier fleet expected to be calling at Grays Harbor, assuming bridge widening and channel deepening, is shown in table 11. The vessels range in size from 15,000 to 45,000 DWT. Only two log vessels smaller than 15,000 DWT called at Grays Harbor in 1980 compared with 25 in 1973, so 15,000 DWT appeared to be a reasonable lower limit. At the other end of the spectrum, the upper limit on future timber carrier size was assumed to be 45,000 DWT, since the 44,000 DWT Hoegh class vessels now calling at Grays Harbor are the largest timber carriers in the world fleet. The largest vessel that can call above the bridge is 35,000 DWT, even with bridge replacement, because of length limitations restricting vessel length to the 600 to 620-foot range.

SECTION III

WOODCHIP CARRIER ANALYSIS

1. Introduction. The woodchip carrier fleet was created to supply Japan's paper and board industry with pulpwood shipped in the form of woodchips. North America is the main source of chips, but Japan also imports significant tonnages from Australia, New Zealand, Malaysia, the Phillippines, and the USSR. The principal port in Japan for receiving woodchips is probably Shimizu, but Grays Harbor cargoes were also unloaded at Tomakomai, Ishinamaki, Iwakuni, Kushiro, and Nagoya in 1980. Nearly all the woodchip carriers operating in the Pacific are Japanese-flag, and were built in response to long-term freight contracts or cargo guarantees. Outside the Japanese trades there is little demand for specialized vessels of this type. Bulk woodchip carriers are unique from conventional bulk carriers because of the density of the cargo. Woodchips stow at one-half to one-third the density of other bulk commodities such as grain and phosphate rock. Woodchip carriers are therefore considerably deeper and slightly wider beamed than conventional bulk carriers. Even at that, a typical chip ship does not have sufficient cubic capacity to stow more than about 70 percent of its deadweight capacity. Conventional bulk carriers hauling chips would carry an even smaller percentage of their deadweight capacity. Cubic capacity would be a more meaningful measure of chip ship capacity than deadweight, but more complete statistics are available on chip ships by deadweight than cubic capacity, so deadweight measures are generally used.

2. World Woodchip Carrier Fleet in 1980. The 1976 and 1980 Bulk Carrier Registers both contained a listing of woodchip carriers. A comparison of the two listings provided some information on how the chip carrier fleet had changed between 1976 and 1980. The 1976 register listed 74 carriers in the world fleet ranging in size from 14,814 DWT to the 56,986 DWT Eden Maru. Fourteen vessels listed in the 1976 register were shown in the 1980 register under a different name, while six vessels previously listed in 1976 were not included in the 1980 listing for no apparent reason. The six vessels were an average of 12 years old (counting from construction date to 1981) and should still be in service, since service lives of bulk carriers last about 20 to 25 years. The 1980 register listed 72 vessels, also ranging in size from 14,814 to 56,986 DWT, 18 of which were "new" since 1976. As mentioned above, 14 of the 18 were simply older vessels under new names, but the remaining four vessels had been built since the 1976 register was published. These four vessels ranged from 38,000 to 42,000 DWT, which says chip carriers in this size range will be in service through the year 2000 and should be included in a future fleet analysis. Overall, the woodchip carrier fleet did not change very much from 1976 to 1980. Of the 74 vessels listed in 1976, 20 "disappeared" by 1980, 14 "reappeared" under different names, and four new vessels were built. Thus, the fleet

count dropped from 74 to 54, increased to 68, and finally to 72. A comparison of the listings in the two registers indicated that the 1976 listing was the more complete of the two, but it needed to be updated by adding the four new vessels that were built after the 1976 listing was published. Table 12 thus summarizes the distribution of size and other vessel characteristics of a 78-vessel world woodchip carrier fleet based on the listing in the 1976 Bulk Carrier Register, updated to 1980. The length, beam, and design draft values are plotted against deadweight tons in figure 4. The world woodchip carrier fleet distribution shows a cluster of vessels in the 20,000-29,999 DWT category and another cluster in the 40,000-49,999 DWT category, with 61 percent of the fleet equal to or exceeding 30,000 DWT. Vessels in the 30,000 DWT and larger groups are relatively newer, averaging about 7 years in service compared with about 12 years for vessels under 30,000 DWT. The newest chip carriers, built in or after 1977, are in the 40,000 DWT class with drafts of about 36 feet. Although the woodchip carrier fleet has not grown rapidly since the mid-1970's in terms of numbers of vessels, the newer vessels that have been built show a trend toward larger, deeper draft vessels.

3. Grays Harbor Woodchip Carrier Fleet in 1980. Twelve woodchip carriers called at Grays Harbor in 1980 and departed with a total of 183,123 short tons of woodchips, averaging 15,960 short tons per carrier or 58 percent of short ton deadweight capacity (i.e., 15,260/23,627 x 1.12). The variation in vessel size was very small, ranging from 22,110 DWT to 24,813 DWT and averaging 23,627 DWT as shown in table 13. Several vessels made two or more repeat calls at Grays Harbor during the year, and four vessels made a second port of call after leaving Grays Harbor. Woodchip vessels departing at less than full capacity (i.e., those making a second port of call) contributed to making the average departure draft of 28.95 feet 9 percent less than the average design draft of 31.77 feet. The light density of the woodchip cargo also contributed to sailing draft being less than design draft. (Inbound draft for the vessels, which all arrived empty, averaged 21.75 feet.) A comparison of table 13 with table 12 shows that the vessels that called at Grays Harbor in 1980 were much smaller in terms of DWT, NRT, length, beam, and draft than the average size vessel in the world fleet (e.g., 23,627 DWT vs. 34,300 DWT). Woodchip carriers calling at Grays Harbor are comparatively small because their width or beam is restricted by the 125-foot horizontal clearance of the Union Pacific Railroad bridge on the Chehalis River at Aberdeen. Chip carriers must pass through this bridge opening to reach the chip loading facility upstream of the bridge. Therefore, woodchip vessel beams seldom exceed 82 feet, and this typically limits vessel size to less than 30,000 DWT.

4. Grays Harbor Woodchip Carrier Fleet in 1973. In 1973, 18 woodchip vessels called at Grays Harbor and departed with a total of 302,075 short tons of chips, averaging 16,872 tons per vessel or 63 percent of short ton deadweight capacity. Average sail draft for the 15 vessels in the 20,000-29,000 DWT group, where most of the draft data

was available, was 89 percent of average design draft. Table 14 summarizes the vessel characteristics that were available for these 18 vessels. The limitations on vessel beam and size imposed by the railroad bridge are again evident, as 17 of the 18 vessels were under 30,000 DWT. The weighted average of the vessel sizes shown in table 14 is 23,880 DWT, almost the same as in 1980. While the world woodchip carrier fleet has shown a trend toward larger, deeper draft vessels, the fleet calling at Grays Harbor has historically remained relatively undersized and unchanged. The average size (i.e., DWT, length, beam, and draft) of woodchip vessels calling at Grays Harber will not increase very dramatically in the future as long as the railroad bridge restricts vessel beams to about 82 feet. On the other hand, potential economies of scale savings would accrue to shippers if the bridge were widened to allow the larger, more cost efficient vessels of the world fleet to call at the chip loading facility.

SECTION IV

FORECAST OF FUTURE WOODCHIP CARRIER FLEET

1. 1975 Port System Study. The 1975 *Port System Study* provided the only detailed analysis of the future woodchip carrier fleet. The following discussion is based on that 1975 study. In February 1974, 38 woodchip vessels were on order from the world's shipyards. The size distribution of these ships, as shown in figure 5, reveals a concentration of ships in the 40,000 to 50,000 DWT range. Almost half of the ships were intended for the Japanese flag, and these averaged 43,000 DWT. These ships are intended for the North American Northwest Japan trade, so they are not limited in their dimensions by the Panama Canal. Three of the ships, one at 41,000 DWT and two at 57,000 DWT, exceed the 105.6-foot beam limitation of the Panama Canal. The case of these three ships points up the lack of importance of the Panama Canal in woodchip trades. If future demand stimulates continued growth in the size of woodchip carriers, the growth will not be interrupted by a gap between Panamax ships and super Panamax ships, as is the case with conventional bulkers. The 40-foot draft limitation of the Panama Canal and of many ports in the world similarly does not pose as serious a limitation on woodchip vessels as on conventional bulk carriers. Due to the light density of the cargo and relatively wider beams, woodchip vessels operate at about 80 to 90 percent of their full load draft when at full cubic capacity with chips. The largest woodchip vessels now being built, up to and including 57,000 DWT, have design drafts of only about 38 feet. Length, beam, and design draft data for the vessels on order in 1974 are shown in figure 6.

2. Vessels Ordered After 1974. The 1975 *Port System Study* was updated in November 1980, but the updated version did not contain an extensive analysis of forest products vessels. Regarding woodchip carriers, the updated study simply observed, "Typical of the larger chip ships is the 45,000 DWT *Empress of Eden* with length of 691 feet, beam of 108 feet, and design draft of 38 feet. This ship is in excess of the Panama Canal limit" (page 4-4). The August 1980 issue of Fairplay, "World Ships on Order," listed only one woodchip vessel on order. The ship had the following dimensions: 43,000 DWT, 620 feet long, 106 feet wide, and a design draft of 36 feet. In summary: (a) the majority of the 38 chip carriers on order in 1974 were in the 40,000 to 45,000 DWT range; (b) three vessels built in 1977 averaged 40,000 DWT; and (c) chip carriers under construction in 1980 included the 45,000 DWT *Empress of Eden* and an unnamed 43,000 DWT vessel scheduled for delivery in 1981.

3. Future Trend in Woodchip Carrier Size. Figure 7 shows the projected trend in woodchip vessel size for the period 1974 to 2000 and the maximum size vessels expected to be in service, both as forecasted in the 1975 *Port System Study*. Since no woodchip carriers have yet been built or ordered that exceed 57,000 DWT, the "maximum ship" trend line in figure 7 is too high, at least for 1980. However, the "average ship"

trend line is a little low for 1980, showing about 31,000 DWT as average when 34,300 DWT is the actual average. In spite of these inconsistencies, figure 7 illustrates the trend in chip vessel size is to large vessels and actual data on ships built from 1974 to 1980 tends to support this forecast. The very large vessels forecasted in figure 7, if they are ever built, would probably be dedicated to serve certain high volume terminals, since not all berths could be expected to be capable of accommodating such large ships. The Grays Harbor chip loading facility would not presently be regarded as high volume when compared to other facilities in Tacoma and Longview.

4. Woodchip Carriers in The Pacific Coast Subregion. According to the 1975 Port System Study, woodchip exports from the Pacific coast, Puget Sound, and lower Columbia subregions can be expected to continue in the specialized woodchip carriers which have become common in the trade. These subregions were illustrated in figure 2. The average size vessel projected to call at port study subregions is shown in table 15. In forecasting the vessel sizes shown in table 15, the Port System Study assumed that if the woodchip trade was not projected to grow over time, there would be little incentive to expand the terminal facilities to accommodate much larger ships or much larger accumulations of cargo. The study projected the woodchip trade in the Pacific Coast subregion, which includes Grays Harbor, to remain constant over the forecast period. Accordingly, the study forecasted that the average size ship calling at Pacific coast chip berths in the future would not be much larger than the present average, as shown in table 15. The study concluded that in spite of the lower average size in service from the Pacific coast subregion, large ships may be expected to call on occasion for partial cargoes.

5. Bridge Restrictions. The Port System Study did not mention the horizontal clearance restriction of the railroad bridge at Aberdeen as a factor in limiting woodchip vessel size. However, the bridge is probably the biggest obstacle because, regardless of whether the Grays Harbor woodchip trade goes up or down, better than 60 percent of the woodchip carriers in the world fleet cannot call at Grays Harbor because they cannot fit through the bridge opening. While the study may have a point in assuming terminal facilities would not expand if trade were not also expected to expand, a similar argument is not as persuasive in forecasting vessel sizes. As rapidly rising world oil prices translate into higher diesel fuel prices, costs of deep-draft shipping will continue to escalate. Forest products are relatively low-valued commodities, as compared with autos or similar manufactured products, and are bulk in nature. Bulk commodities are needed in order to take advantage of mechanized handling techniques for the transloading operations that are invariably required for marine movements. Low-valued commodities are required not only to hold down inventory carrying costs in transit but also to hold down storage costs at the gathering point for the waterborne shipment. Large volumes must be gathered in order to take advantage of large vessel carrying capacity. The cost of storing

high-valued commodities for marine movement would be prohibitive. Transportation costs are a significant factor in the final price of relatively low-valued commodities, and the commodities can absorb only small transportation cost increases without affecting demand. If the demand for a commodity is price elastic and transportation costs represent a significant percentage of the total cost, shippers will be extremely sensitive to transportation costs and policies.

6. Projected Woodchip Carrier Fleet for Grays Harbor. Forest products companies shipping out of Grays Harbor rely heavily on foreign export markets because high transportation costs hinder them from effectively competing for markets in the midwestern and eastern United States with southern companies. It would seem, then, that Pacific coast shippers would have strong economic incentives to keep waterborne transportation costs as low as possible. This means using the largest, most cost efficient vessels available, even if the future growth curve for a particular commodity may be flat or declining. Therefore, the Port System Study conclusion that Pacific coast subregion woodchip carriers will increase in size very little by the year 2000 is valid as long as the railroad bridge restricts growth of average vessel size. However, if the bridge restrictions were removed, as is expected to be the case under the with project conditions, larger vessels which dominate the world fleet would more than likely start calling at the woodchip facility up to the maximum 620-foot length limitation. The projected woodchip carrier fleet, or the fleet expected to be calling at Grays Harbor assuming bridge widening and channel deepening, is shown in table 16.

TABLE 1

TIMBER CARRIERS IN THE WORLD FLEET AS OF 1975

Deadweight (long tons)	Number of Ships	Percentage of Total	Avg. DWT (tons)	Avg. NRT (tons)	Avg. Length (feet)	Avg. Beam (feet)	Avg. Design Draft (feet)	Avg. Age (years)	Avg. Speed (knots)
10,000-14,999	19	13	12,668	5,256	461.2	66.6	27.4	8.2	14.0
15,000-19,999	61	43	16,948	6,588	494.2	72.6	29.1	6.9	14.6
20,000-24,999	10	7	22,360	8,805	556.7	77.8	31.4	5.4	15.1
25,000-29,999	30	21	26,757	10,470	576.9	82.1	33.5	3.3	14.9
30,000-34,999	18	13	32,470	13,422	607.7	87.7	35.9	4.2	15.5
35,000-39,999	4	3	37,111	13,518	635.0	86.1	37.7	5.5	15.5
TOTAL	142	100							
FLEET AVERAGE			21,453	8,481	530.6	76.5	31.1	5.8	14.8

Sources: Bulk Carrier Register, 1976, 1980; and Record of the American Bureau of Shipping, 1980.

NOTE: The timber carrier fleet was listed in the 1975 Register but only by name and DWT. All the other vessel characteristics were taken from the sources listed above. Average age is number of years between 1975 and year of vessel construction. DWT = deadweight tons. NRT = net registered tons.

TABLE 2

LOG VESSELS CALLING AT GRAYS HARBOR IN 1980

Deadweight (long tons)	No. of Ships	Percentage of Total	No. in Sample	Avg. DWT (tons)	Avg. NRT (tons)	Avg. Length (feet)	Avg. Beam (feet)	Avg. Design Draft (feet)	Avg. Sail Draft (feet)	Avg. Age (years)
10,000-14,999	2	1	2	12,295	4,765	397.7	63	29.7	29.0	9.0
15,000-19,999	60	38	32	18,068	7,115	494.0	75.1	30.6	31.2	8.0
20,000-24,999	63	39	21	23,055	9,347	541.9	79.9	31.8	32.2	5.6
25,000-29,999	30	19	17	26,833	10,467	563.1	83.0	33.6	33.1	5.2
30,000-34,999	5	3	5	32,742	12,635	588.4	91.4	36.1	29.8	4.7
35,000-39,999	0	0	--	--	--	--	--	--	--	--
TOTAL	160	100	77							
FLEET AVERAGE				22,061	8,764	527.7	78.8	31.8	31.9	5.7

Source: Port of Grays Harbor Monthly Shipping Reports, 1980. Average age is number of years between 1980 and year of vessel construction.

TABLE 3

LOG VESSELS CALLING AT GRAYS HARBOR IN 1973

Deadweight Tons (long tons)	No. of Ships	Percentage of Total	Average DWT (tons)	Average NRT (tons)	Average Length (feet)	Average Beam (feet)	Average Design Draft (feet)	Average Age (years)
10,000-14,999	25	18	14,301	5,712	466.24	68.13	28.68	4
15,000-19,999	104	75	17,943	6,737	496.67	73.87	30.67	3
20,000-24,999	3	2	20,357	9,932	507.19	77.05	32.61	2
25,000-29,999	4	3	26,885	10,429	574.17	78.58	35.36	2
30,000-34,999	3	2	32,389	13,232	597.11	88.61	35.90	1
35,000-39,999	0	0	-	-	-	-	-	-
TOTAL	139	100						
FLEET AVERAGE			17,893	6,857	495.75	73.34	30.60	3.1

Source: Port of Grays Harbor Monthly Shipping Reports, 1973. Average age is number of years between 1973 and year of vessel construction.

TABLE 4

COMPARISON OF LOG VESSEL FLEETS
GRAYS HARBOR, 1973 AND 1980

Characteristic	Fleet Average In 1973	Fleet Average In 1980	Change	Percent Change
Size	17,893.00 DWT	22,061.0 DWT	4,168.00 DWT	23
Length	495.75 feet	527.7 feet	31.95 feet	6
Beam	73.34 feet	78.8 feet	5.46 feet	7
Design Draft	30.6 feet	31.8 feet	1.2 feet	4
Sail Draft	29.5 feet	31.9 feet	2.4 feet	8

Source: Port of Grays Harbor Monthly Shipping Reports, 1973 and 1980.

TABLE 5

LOG VESSEL DRAFTS AT GRAYS HARBOR IN 1980

A. ALL VESSELS INCLUDING PARTIALLY LOADED VESSELS

Sail Draft Category	Number of Ships	Percentage of Total	Avg. DWT (l. tons)	Avg. NRT (l. tons)	Avg. Cargo Load (s. tons)	Avg. Arrival Draft (feet)	Avg. Sail Draft (feet)	Avg. Design Draft (feet)
Below 28'	32	20	22,896	9,037	8,535	20-00	24-07	32-03
28'-00" to 29'-11"	14	9	20,697	8,143	13,087	20-01	29-00	31-03
30'-00" to 31'-11"	43	27	18,989	7,744	12,622	21-05	31-00	30-07
32'-00" to 33'-11"	53	33	22,012	8,705	16,350	21-04	33-00	31-07
34'-00" or more	18	11	25,089	9,893	19,465	23-02	34-02	33-10
TOTAL	160	100						
FLEET AVERAGE			21,593	8,592	13,829	21.18	30.54	31.66

B. FULLY LOADED VESSELS ONLY

Sail Draft Category	Number of Ships	Percentage of Total	Avg. DWT (l. tons)	Avg. NRT (l. tons)	Avg. Cargo Load (s. tons)	Avg. Arrival Draft (feet)	Avg. Sail Draft (feet)	Avg. Design Draft (feet)
Below 28'	0	0	-	-	-	-	-	-
28'-00" to 29'-11"	5	7	17,396	6,855	15,020	19-07	29-03	30-02
30'-00" to 31'-11"	24	31	18,359	7,767	15,698	19-03	31-01	30-03
32'-00" to 33'-11"	35	46	21,975	8,646	19,188	20-06	33-00	31-07
34'-00" or more	12	16	25,134	9,968	23,335	20-02	34-01	33-10
TOTAL	76	100						
FLEET AVERAGE			21,039	8,460	18,478	20.00	32.29	31.43

TABLE 5 (con.)

C. VESSELS PARTIALLY LOADED INBOUND1/

Sail Draft Category	Number of Ships	Percentage of Total	Avg. DWT (l. tons)	Avg. NRT (l. tons)	Avg. Cargo Load (s. tons)	Avg. Arrival Draft (feet)	Avg. Sail Draft (feet)	Avg. Design Draft (feet)
Below 28'	2	5	28,961	11,668	10,055	23-04	27-00	34-07
28'-00" to 29'-11"	2	5	17,741	6,657	5,652	26-06	29-07	30-05
30'-00" to 31'-11"	13	34	17,762	6,977	6,290	25-05	31-00	30-00
32'-00" to 33'-11"	15	40	21,901	8,792	10,254	25-03	33-01	31-04
34' or more	6	16	24,999	9,743	11,727	28-01	34-03	34-02
TOTAL	38	100						
FLEET AVERAGE			21,134	8,364	8,902	25.73	32.08	31.45

1/Defined as inbound draft of 23 feet or more unless otherwise specified in port records.

D. VESSELS PARTIALLY LOADED OUTBOUND2/

Sail Draft Category	Number of Ships	Percentage of Total	Avg. DWT (l. tons)	Avg. NRT (l. tons)	Avg. Cargo Load (s. tons)	Avg. Arrival Draft (feet)	Avg. Sail Draft (feet)	Avg. Design Draft (feet)
Below 28'	32	67	22,896	9,037	8,535	20-00	24-07	32-03
28'-00" to 29'-11"	7	15	23,898	9,487	13,831	18-07	28-08	32-05
30'-00" to 31'-11"	6	12	24,170	9,318	14,039	20-11	30-11	32-02
32'-00" to 33'-11"	3	6	22,994	8,959	13,702	18-10	32-10	32-08
34' or more	0	0	-	-	-	-	-	-
TOTAL	48	100						
FLEET AVERAGE			23,205	9,187	10,300	19.83	27.15	32.29

2/Defined as outbound draft of 28 feet or less unless otherwise specified in port records.

TABLE 6

LUMBER VESSELS CALLING AT GRAYS HARBOR IN 1980

Deadweight (long tons)	Number of Ships	Percentage of Total	Avg. DWT (l. tons)	Avg. NRT (l. tons)	Avg. Cargo Load (s. tons)	Avg. Length (feet)	Avg. Beam (feet)	Avg. Design Draft (feet)	Avg. Sail Draft (feet)	Avg. Age (years)
10,000-14,999	0	0	-	-	-	-	-	-	-	-
15,000-19,999	3	23	17,627	6,750	9,524	492.3	72.7	30.1	28.07	5
20,000-24,999	0	0	-	-	-	-	-	-	-	-
25,000-29,999	5	38	26,038	10,254	9,185	569.9	82.7	32.7	27.00	5.8
30,000-34,999	1	8	30,295	12,307	6,539	645.1	75.1	35.6	31.05	11
35,000-39,999	0	0	-	-	-	-	-	-	-	-
40,000 or more	4	31	43,292	16,793	10,802	657.7	101.2	37.9	31.04	4
TOTAL	13	100								
FLEET AVERAGE			29,793	11,639	9,552	585.3	85.5	33.9	29.00	5.5

SOURCE: Port of Grays Harbor Monthly Shipping Reports, 1980. Average age is number of years between 1981 and year of vessel construction.

TABLE 7

Forecast of Average Number of Timber Carriers, Size, and Trade Per Subregion

			Number of Vessel Trips		
Year	Average DWT	Cargo s.t.	Pacific Coast 1/	Puget Sound	Lower Columbia
1980	22,000	23,280	103	258	120
1990	28,000	29,630	81	202	94
2000	35,000	37,040	65	162	76

Source: Port System Study, Volume II, Part 5, March 1975, pages 3-29.

1/Includes only Grays Harbor and Willapa Harbor, as shown in figure 2.

TABLE 8

ASSIGNMENT OF SHIP TYPES TO VESSEL GROUPS
TBS-MARAD MERCHANT FLEET FORECAST - 1978

Conventional General Cargo

01 Freighter
13 Freighter/Nuclear
03 Freighter/Refrigerator
05 Combination Passenger and Cargo
06 Combination/Refrigrator
15 Combination/Nuclear

Partial Container

57 Pallet Carrier
58 Partial Container

Full Containership

09 Containership
45 Container/Car Carrier
55 Container/Rail Carrier
56 Container/Ro/Ro
59 Roll-on/Roll-off

Barge Carrier

50 Barge Carrier
53 Container/Barge Carrier

Neobulk

71 Bulk/Car Carrier
72 Bulk/Containership
74 Bulk/Timber Carrier
11 Car Carrier
60 Timber Carrier
52 Cattle Carrier

Dry Bulk

70 Bauxite Carrier
04 Bulk Carrier
75 Cement Carrier
24 Colliers
76 Limestone Carrier
77 Nickel Carrier
10 Ore Carrier
79 Pellet Carrier
80 Phosphate Carrier
81 Salt Carrier
82 Sand Carrier
83 Urea Carrier
84 Woodchip Carrier

Combination Carriers

73 Bulk/Oil
78 Ore/Bulk/OIl
07 Ore/Oil Carrier

Liquified Gas

22 LPG Tanker
34 LNG Tanker

Liquid Bulk Carrier

30 Asphalt Tanker
31 Asphalt/Bitumen
32 Bitumen
33 Chemical Tanker
35 Molasses Tanker
14 Nuclear Tanker
36 Phosphorus Tanker
37 Solvents Tanker
38 Sulphur Tanker
02 Tanker
08 Whaling Tanker
39 Wine Tanker

Source: Merchant Fleet Forecast of Vessels In U.S. - Foreign Trade, Temple, Barker and Sloane, Inc., Mass., May 1978, p. II-10

TABLE 9

TBS MERCHANT FLEET FORECAST - NEOBULK CARRIERS - PACIFIC COAST

Deadweight Range (000)	Number of Ships in World Fleet	Average DWT Per Vessel	Length (feet)	Beam (feet)	Draft (feet)	Cargo Handling Rate (tons/hr)	Installed Shaft Horsepower	Speed (knots)
1980								
1-15	9		458	68	25	499	6,000	15
15-20	23		493	73	29	495	6,000	14
20-25	8	21,705	563	77	32	541	10,000	16
23-35	7		624	81	35	596	13,000	16
35-60	1		709	100	37	685	15,000	16
60.	0							
1985								
1-15	11		443	66	25	504	6,000	15
15-20	30		493	73	29	559	6,000	14
20-25	14	22,056	564	75	33	609	10,000	16
25-35	9		641	79	35	679	12,000	16
35-60	1		708	99	37	770	15,000	16
60.	0							
1990								
1-15	14		433	64	25	559	5,000	15
15-20	37		492	73	29	623	6,000	14
20-25	21	22,751	565	75	33	677	10,000	16
25-35	13		653	78	35	762	12,000	16
35-60	3		708	99	37	858	15,000	16
60.	1		751	106	44	1,076	18,000	16

TABLE 9 (con.)

Deadweight Range (000)	Number of Ships in World Fleet	Average DWT Per Vessel	Length (feet)	Beam (feet)	Draft (feet)	Cargo Handling Rate (tons/hr)	Installed Shaft Horsepower	Speed (knots)
1995								
1-15	13		414	62	24	610	5,000	14
15-20	39		492	73	29	688	6,000	14
20-25	29	24,429	566	74	33	746	10,000	16
25-35	19		663	77	35	845	12,000	16
35-60	6		708	99	37	946	15,000	16
60.	2		751	106	44	1,187	18,000	16
2000								
1-15	15		398	60	24	665	4,000	14
15-20	45		493	73	29	751	6,000	14
20-25	38		567	73	33	814	10,000	16
25-35	24	26,514	680	75	35	933	12,000	16
35-60	11		708	99	37	1,034	15,000	16
60.	4		751	106	44	1,299	17,000	16

Note: Neobulk carriers are defined in table 8. West Coast refers to entire West Coast, not just Washington State as was the case in figure 2. Number of ships is only for U.S.-foreign trade and, therefore, is not the same as total world fleet.

Source: Merchant Fleet Forecast of Vessels in U.S.-Foreign Trade, Final Report, Section XIII, May 1978.

TABLE 10

FORECAST U.S. SEABORNE TRADE IN FOREST PRODUCTS BY VESSEL SIZE
(thousand million tonne-miles)

(a) 1980

Vessel Size (DWT)	North Atlantic	South Atlantic	Gulf	South Pacific	Great Lakes	North Pacific	Total
20-34,999	10.9	9.3	11.5	9.2	0.2	47.6	88.7
35-49,999	-	-	-	-	-	9.0	9.0
50-79,999	-	-	-	-	-	-	-
80-99,999	-	-	-	-	-	-	-
100,000+	-	-	-	-	-	-	-
Others	1.2	1.0	1.3	1.0	-	3.6	8.1
Total	12.1	10.3	12.8	10.2	0.2	60.2	105.8

(b) 1990

Vessel Size (DWT)	North Atlantic	South Atlantic	Gulf	South Pacific	Great Lakes	North Pacific	Total
20-34,999	15.3	13.0	19.1	11.5	0.2	59.7	118.8
35-49,999	-	-	-	-	-	15.3	15.3
50-79,999	-	-	-	-	-	-	-
80-99,999	-	-	-	-	-	-	-
100,000+	-	-	-	-	-	-	-
Others	1.2	1.1	1.6	0.9	-	1.5	6.3
Total	16.5	14.1	20.7	12.4	0.2	76.5	140.4

TABLE 10 (con.)

(c) 2000

Vessel Size (DWT)	North Atlantic	South Atlantic	Gulf	South Pacific	Great Lakes	North Pacific	Total
20-34,999	22.6	18.5	24.2	15.9	0.2	68.7	150.1
35-49,999	-	-	-	-	-	22.9	22.9
50-79,999	-	-	-	-	-	-	-
80-99,999	-	-	-	-	-	-	-
100,000+	-	-	-	-	-	-	-
Others	1.2	1.0	1.3	0.8	-	-	4.3
Total	23.8	19.5	25.5	16.7	0.2	91.6	177.3

Note: The term tonne indicates metric tons (equivalent to 1.102 short tons or 0.984 long tons). The nautical mile is 1,852 meters or 6,076.4 feet or 1.1508 miles. References to tonne-miles are given as mmm or one thousand million, and are a multiplication of cargo tonnes and nautical miles.

Source: Development of a Standardized U.S. Flag Dry-Bulk Carrier, Appendix C, January 1979, page 179.

TABLE 11

PROJECTED TIMBER CARRIER FLEET
GRAYS HARBOR

Vessel Size (DWT)	Cargo Load (short tons)1/	Design Draft (feet)	Sail Draft (feet)	Beam (feet)	Length (feet)
15,000	13,400	29	29	70	490
20,000	17,900	31	31	77	530
25,000	22,400	33	33	82	560
30,000 2/	26,900	34	34	88	590
35,000	31,400	35	35	92	620
37,000	33,200	35	35	95	630
40,000	35,800	36	36	97	640
45,000	40,300	37	37	102	658

1/Figured on 80 percent of short-ton deadweight capacity (i.e., DWT x 1.12 x .80) and rounded to nearest 100 tons.

2/Beam on this size vessel requires UPRR bridge widening. This is also the largest vessel that can call above the bridge because of the 600-foot length limitation.

NOTE: Numbers in table are rounded averages of world fleet and Grays Harbor vessel characteristics. Actual dimensions for a specific vessel may be slightly larger or smaller than those shown in the table due to the use of averages.

TABLE 12

WOODCHIP CARRIERS IN THE WORLD FLEET AS OF 1980

Deadweight Tons (long tons)	Number of Ships	Percent of Total	Average DWT (tons)	Average NRT (tons)	Average Length (feet)	Average Beam (feet)	Average Draft (feet)	Average Age (years)	Average Speed (knots)
10,000-19,999	3	4	16,964	8,591	528.80	72.67	28.55	12.7	15.0
20,000-29,999	27	35	24,088	14,277	568.64	81.34	32.03	12.1	14.4
30,000-39,999	17	21	35,144	20,921	632.31	94.76	34.23	7.8	14.9
40,000-49,999	27	35	43,064	26,508	660.03	101.13	36.48	7.0	14.8
50,000-59,999	4	5	54,777	32,720	716.14	111.51	38.37	7.7	14.4
Total	78	100							
Fleet Average			34,300	20,648	619.78	92.25	34.23	9.2	14.7

Source: Bulk Carrier Register, 1976, 1980, and Record of the American Bureau of Shipping, 1980. Average age is number of years between 1984 and year of vessel construction.

TABLE 13

WOODCHIP CARRIERS CALLING AT GRAYS HARBOR IN 1980

Deadweight Tons (long tons)	Number of Ships	Average DWT (l. tons)	Average NRT (tons)	Average Length (feet)	Average Beam (feet)	Average Age (years)	Average Sail Draft (feet)	Average Design Draft (feet)
10,000-19,999	0							
20,000-29,999	12	23,627	14,013	553.98	79.37	10.3	28.95	31.77
30,000-39,999	0							
40,000-49,999	0							
50,000-59,999	0							
Total	12							

Source: Port of Grays Harbor Monthly Shipping Reports, 1980.

TABLE 14

WOODCHIP CARRIERS CALLING AT GRAYS HARBOR IN 1973

Deadweight Tons (long tons)	Number of Ships	Average DWT (l. tons)	Average NRT (tons)	Average Length (feet)	Average Beam (feet)	Average Age (years)	Average Sail Draft (feet)	Average Design Draft (feet)
10,000-19,999	2	15,518	9,293	N/A	N/A	N/A	27.25	N/A
20,000-29,999	15	24,249	13,194	572.29	80.66	13.5	27.96	31.57
30,000-39,999	1	33,555	13,871	608.58	85.30	8.0	28.42	36.57
40,000-49,999	0							
50,000-59,999	0							
Total	18							

Source: Port of Grays Harbor Monthly Shipping Reports, 1973.

TABLE 15

FORECAST OF WOODCHIP CARRIER SIZE IN PORT STUDY SUBREGIONS

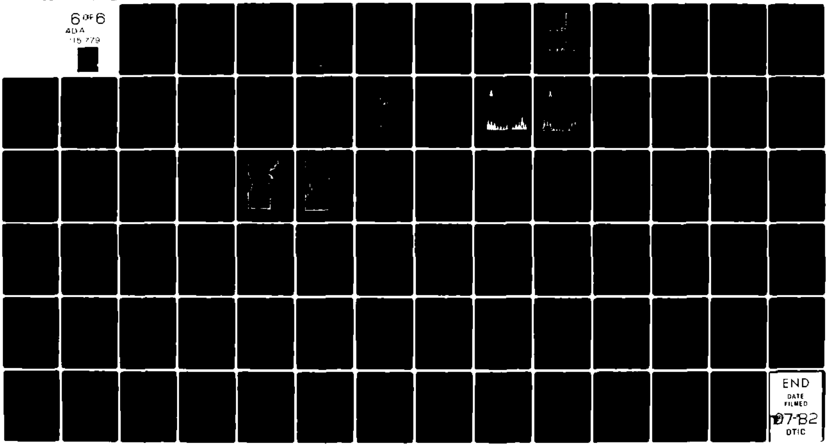
Year	Pacific Coast Average DWT	Puget Sound and Lower Columbia Average DWT
1980	22,000	30,500
1990	26,000	47,500
2000	30,000	65,000

Source: Port System Study, Volume II, Pages 3-27, March 1975.

AD-A115 779 CORPS OF ENGINEERS SEATTLE WA SEATTLE DISTRICT F/G 13/2
INTERIM FEASIBILITY REPORT AND DRAFT ENVIRONMENTAL IMPACT STATE--ETC (U)
JUN 82

UNCLASSIFIED NL

6 OF 6
ADA
115 779



END
DATE
FILMED
07-82
DTIC

TABLE 16

PROJECTED WOODCHIP CARRIER FLEET
GRAYS HARBOR

Vessel Size (DWT)	Cargo Load (short tons)1/	Design Draft (feet)	Sail Draft (feet)2/	Beam (feet)	Length (feet)
22,000	15,500	31	27	79	555
24,000	16,900	31	28	81	570
26,000	18,300	32	29	83	575
28,000	19,800	33	30	85	590
30,000 3/	21,200	33	30	88	600

1/Sixty-three percent of short-ton deadweight capacity (i.e., DWT x 1.12 x .63) and rounded to nearest 100 tons.
2/Figured on design draft times 90 percent and rounded to nearest whole foot.
3/Beam on this size vessel requires UPRR bridge widening. This is the maximum size vessel, on average, that can call above the bridge because of the 600-foot length limitation.

NOTE: Numbers in table are rounded averages of world fleet and Grays Harbor woodchip vessel characteristics. Actual dimensions for a specific vessel may be slightly larger or smaller than those shown in the table due to the use of averages.

TABLE 17
COST PER TON - TIMBER CARRIERS
OCTOBER 1981 PRICES

Vessel Size (DWT) 1/	Vessel Size (DWT) 2/	Sail Draft (feet) 3/	Cargo Load (short tons) 4/	Loading Rate (tons per hour) 5/	Time in Port (hours) 6/	Vessel Cost Per Hour in Port 7/	Total Cost in Port 8/	Time at Sea (hours) 9/	Vessel Cost Per Hour at Sea 10/	Total Cost at Sea 11/	Total Cost in Port and at Sea	Cost Per Ton 12/
15,000	16,371	29	14,668	628	23	$588	$13,524	607	$758	$460,106	$473,630	$32.29
20,000	19,696	31	17,648	655	27	635	17,145	607	832	505,024	522,169	29.59
25,000	24,928	33	22,335	711	31	699	21,669	531	936	497,016	518,685	23.22
30,000	29,001 13/	34	25,985	763	34	744	25,296	531	1,009	535,779	561,075	21.59
35,000	34,062 14/	35	30,520	776	39	794	30,966	531	1,094	580,914	611,880	20.05
37,000	36,997	35	33,149	821	40	822	32,880	531	1,140	605,340	638,220	19.25
40,000	40,120	36	35,948	850	42	850	35,700	531	1,187	630,297	665,997	18.53
45,000	44,367	37	39,753	863	46	885	40,710	531	1,248	662,688	703,398	17.69

1/ Vessel size refers to a range. For example, 15,000 DWT = 15,000 DWT-19,999 DWT. Numbers shown are rounded averages as used in economic appendix.

2/ Numbers shown are actual averages for vessels in that size range, based on 1980 vessel fleet data for Grays Harbor.

3/ Measured at the stern of a fully laden vessel. An average of vesel drafts for the vessel sizes shown in column 2.

4/ Figured on 80 percent of short-ton cargo capacity (i.e., DWT x 1.12 x .80). Excludes 20 percent for stores, supplies, food, etc.

5/ Loading rates shown are for 1990, project year one. Data source is TBS Merchant Fleet Forecast from table 9 of this exhibit.

6/ Cargo load divided by loading rate.

7/ Vessel costs per hour are based on O.C.E. data for January 1981, updated to October 1981. Costs for each vessel size taken from interpolated O.C.E. data using regression analysis. Cost per hour in port = 92296.8740 x DWT $^{(0.4102)}$ ÷ (350 days x 24 hours/day).

8/ Hours in port times vessel cost per hour in port.

9/ Based on 8,500 nautical miles round-trip distance (between Grays Harbor and Japan) divided by average vessel speed of 16.0 knots for vessels over 20,000 DWT and 14.0 knots for vessels less than or equal to 20,000 DWT.

10/ Cost per hour at sea = 49893.7901 x DWT $^{(0.4998)}$ ÷ (350 days x 24 hours/day).

11/ Hours at sea times vessel cost per hour at sea.

12/ Total cost in port and at sea divided by cargo load in short tons. Cost per ton for other vessel size not shown in this table = 1289139.9999 x DWT $^{(-0.6187)}$ ÷ 100.

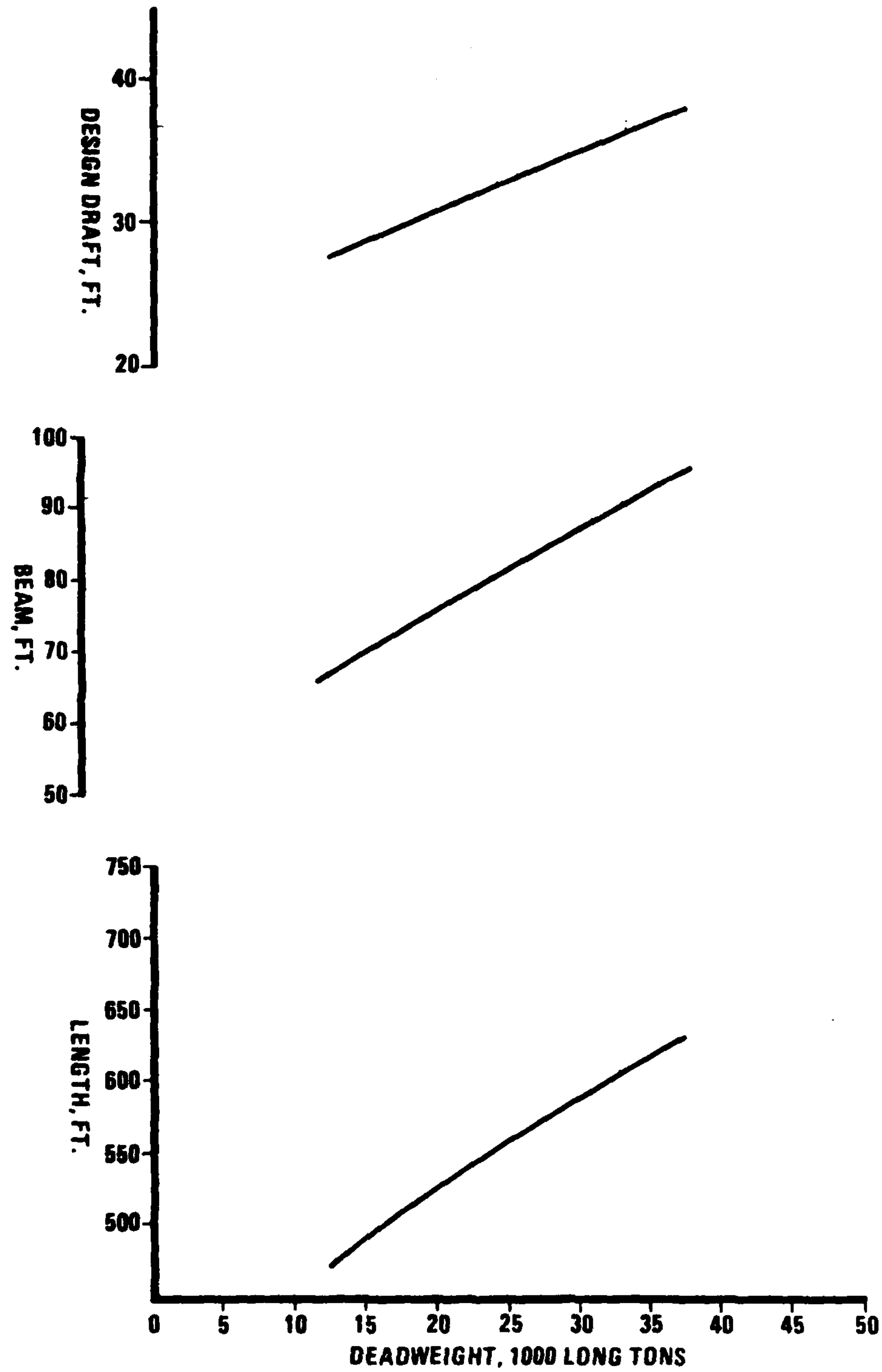
13/ Beam on this vessel (i.e., 88 feet) requires bridge widening.

14/ This size vessel requires both waterway deepening and bridge widening because of draft and beam.

TABLE 18
COST PER TON - WOODCHIP VESSELS
OCTOBER 1981 PRICES

Vessel Size (DWT) 1/	Sail Draft (feet) 2/	Cargo Load (short tons) 3/	Loading Rate (short tons/hr) 4/	Time in Port (hours) 5/	Vessel Cost Per Hour in Port 6/	Total Cost in Port 7/	Time at Sea (hours) 8/	Vessel Cost Per Hour at Sea 9/	Total Cost at Sea 10/	Total Cost in Port and at Sea	Cost Per Ton 11/
22,000	27	15,523	300	52	$664	$34,528	531	$879	$466,749	$501,277	$32.29
24,000	28	16,934	300	56	688	38,528	531	918	487,458	525,986	31.06
26,000	29	18,346	300	61	711	43,371	531	956	507,636	551,007	30.03
28,000	30	19,757	300	66	733	48,378	531	992	526,752	575,130	29.11
30,000	30	21,168	300	71	754	53,534	531	1,027	545,337	598,871	28.29
31,000	30	21,874	300	73	764	55,772	531	1,043	553,833	609,605	27.87
32,000	31	22,579	300	75	774	58,050	531	1,060	562,860	620,910	27.50
33,000	31	23,285	300	78	784	61,152	531	1,077	571,887	633,039	27.19
34,000	31	23,990	300	80	794	63,520	531	1,092	579,852	643,372	26.82
35,000	31	24,696	300	82	803	65,846	531	1,109	588,879	654,725	26.51

1/ Numbers shown are rounded averages as used in the economic appendix.
2/ Figured on 90 percent of design draft and rounded to nearest whole foot.
3/ Figured on 63 percent of short ton cargo capacity (i.e., DWT x 1.12 x .63).
4/ Current loading rate at private woodchip facility in Grays Harbor.
5/ Cargo load divided by loading rate.
6/ Based on 1981 O.C.E. data and $y = 92296.8740 \times DWT^{(0.4102)} \div (350 \text{ days} \times 24 \text{ hours/day})$.
7/ Hours in port times cost per hour in port.
8/ Based on 8,500 nautical miles round trip between Grays Harbor and Japan and vessel speed of 16.0 knots.
9/ Based on 1981 O.C.E. data and $y = 49893.7901 \times DWT^{(0.4998)} \div (350 \text{ days} \times 24 \text{ hours/day})$.
10/ Hours at sea times vessel cost per hour at sea.
11/ Total cost in port and at sea divided by cargo load.



TIMBER VESSEL CHARACTERISTICS
1975 WORLD FLEET
FIGURE 1

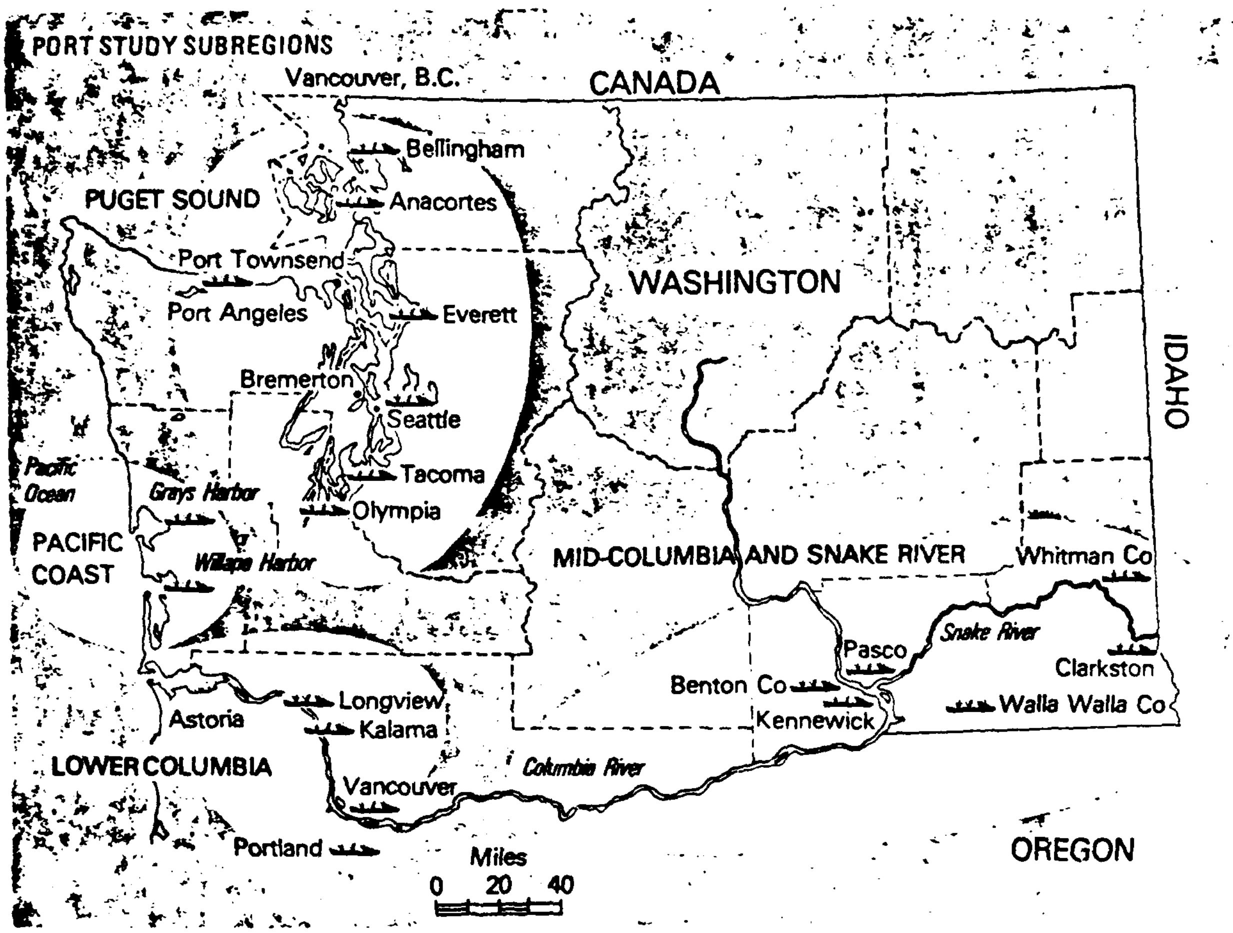


FIGURE 2
Port System Study Subregions

Source: Port System Study, March 1975.

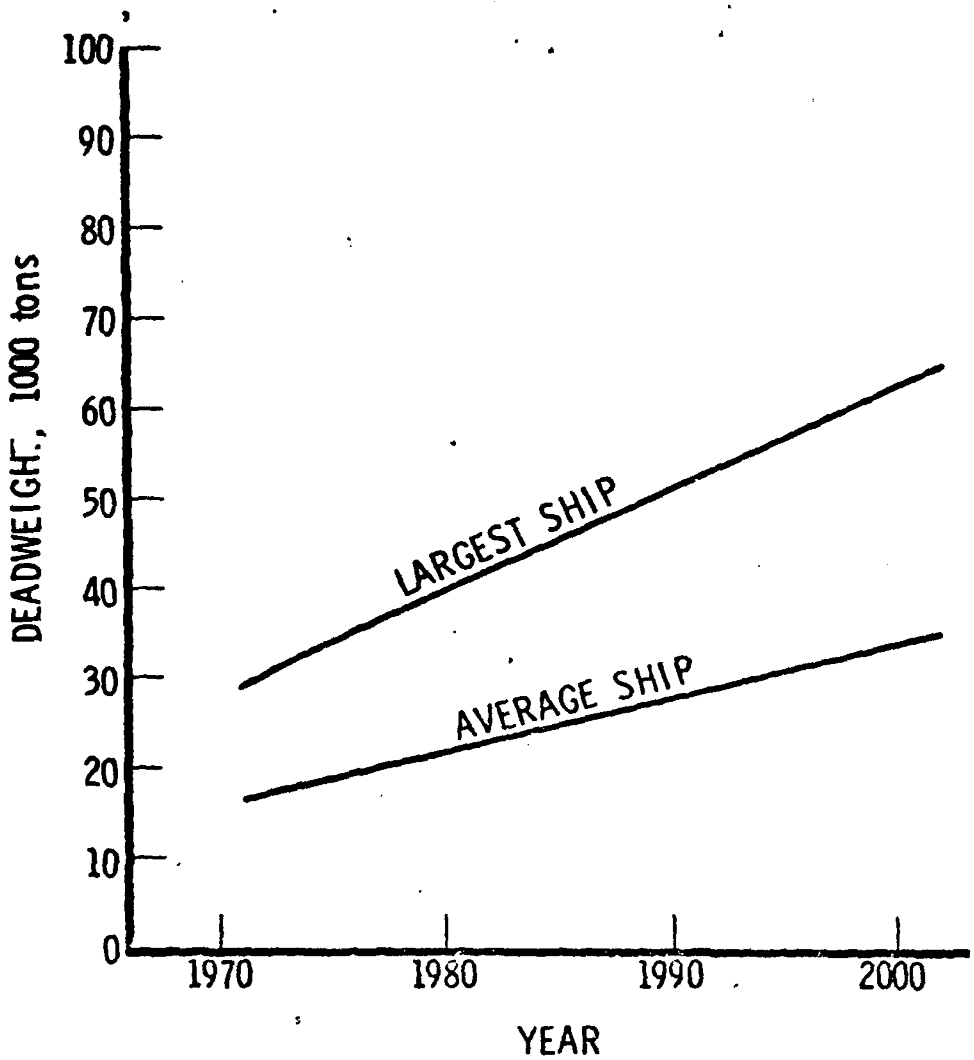
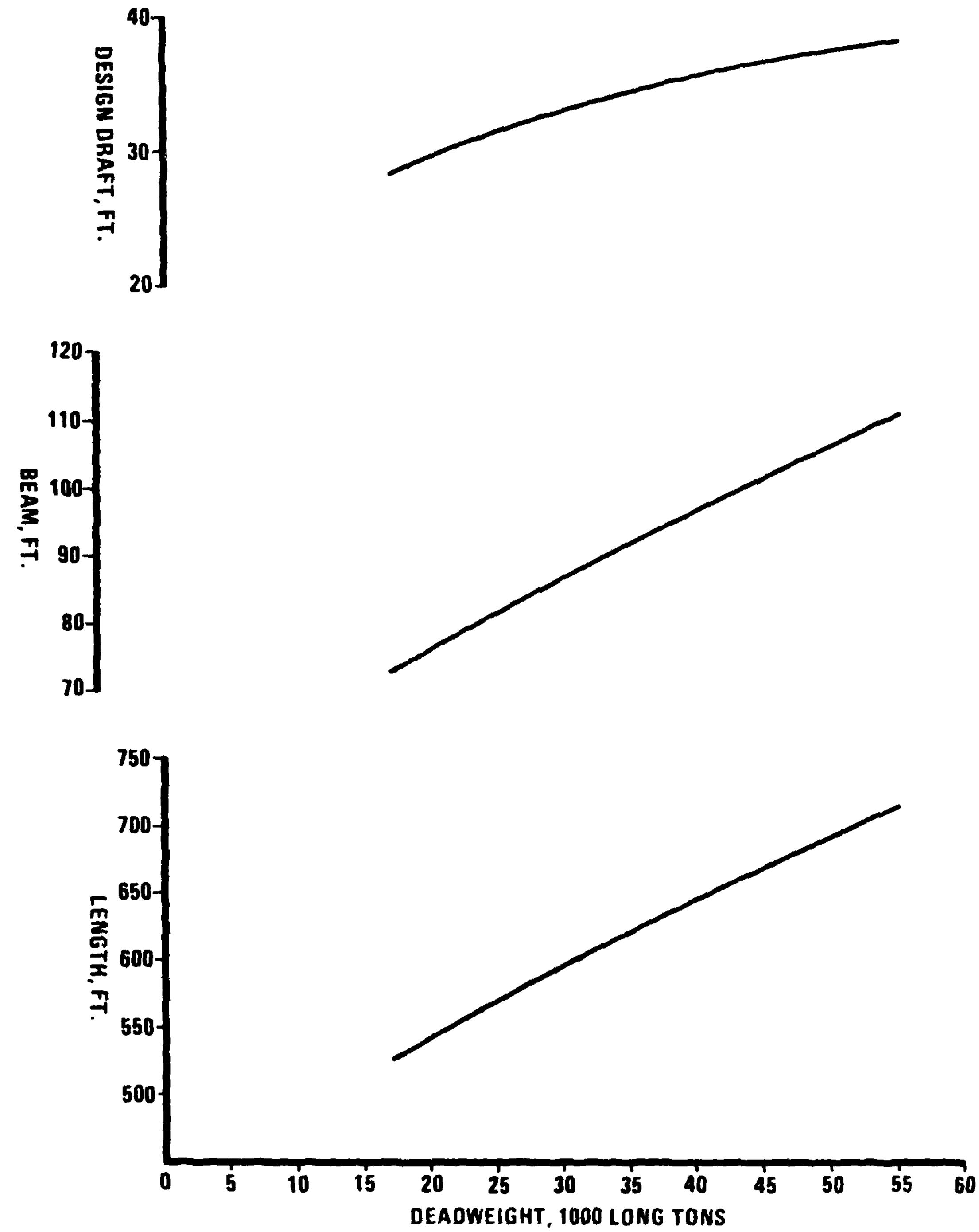


Figure 3
Forecast of Trend in Average and Maximum Size of Timber Carriers

Source: Port System Study for the Public Ports of Washington State and Portland, Oregon, Volume II, Part 5, pages 1-46, March 1975.



WOODCHIP VESSEL CHARACTERISTICS
1980 WORLD FLEET
FIGURE 4

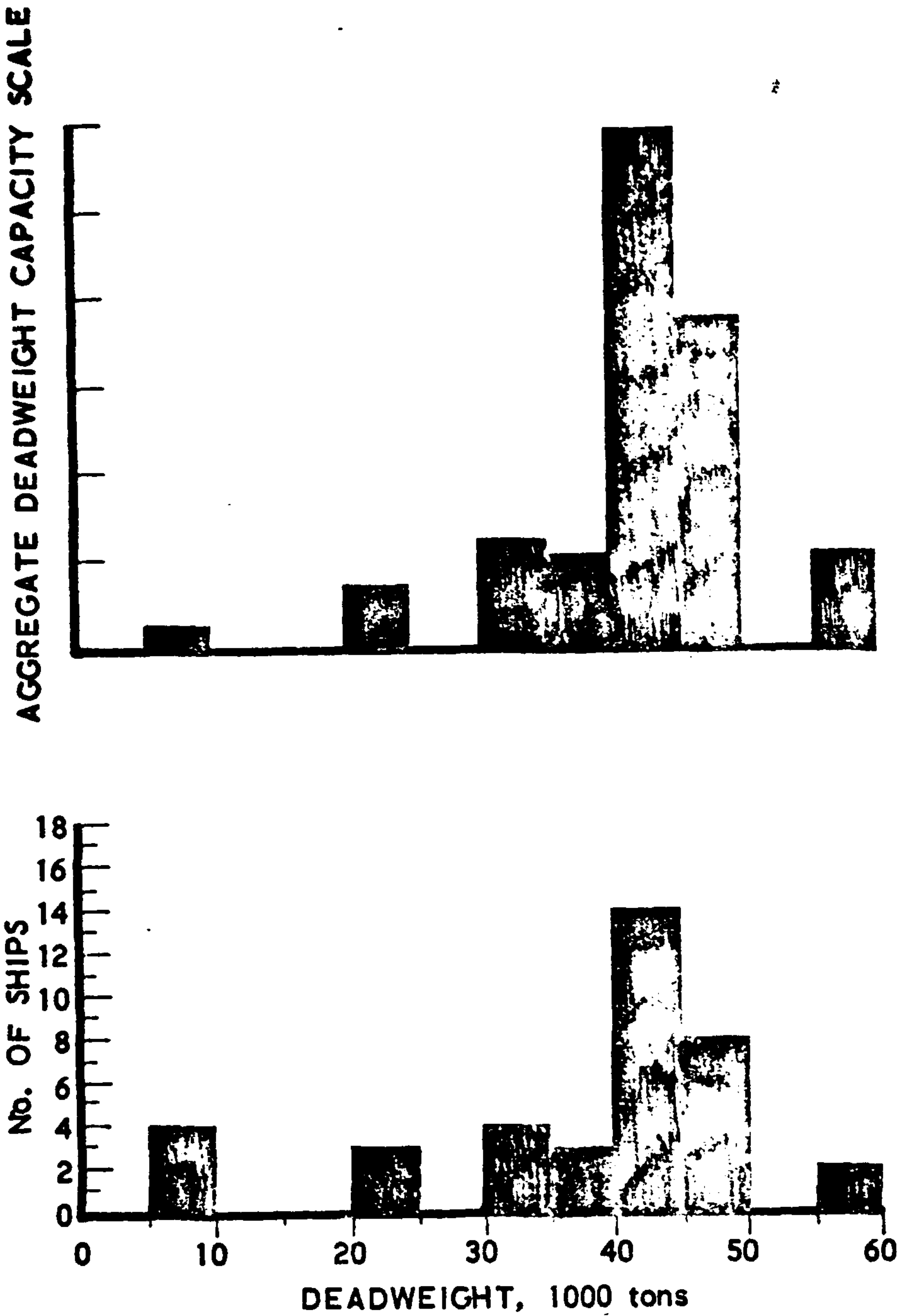


Figure 5
Distribution in Size of Woodchip Carriers on Order in February 1974

Source: Fairplay, "World Ships on Order" (February 1974); and Port System Study, 1975

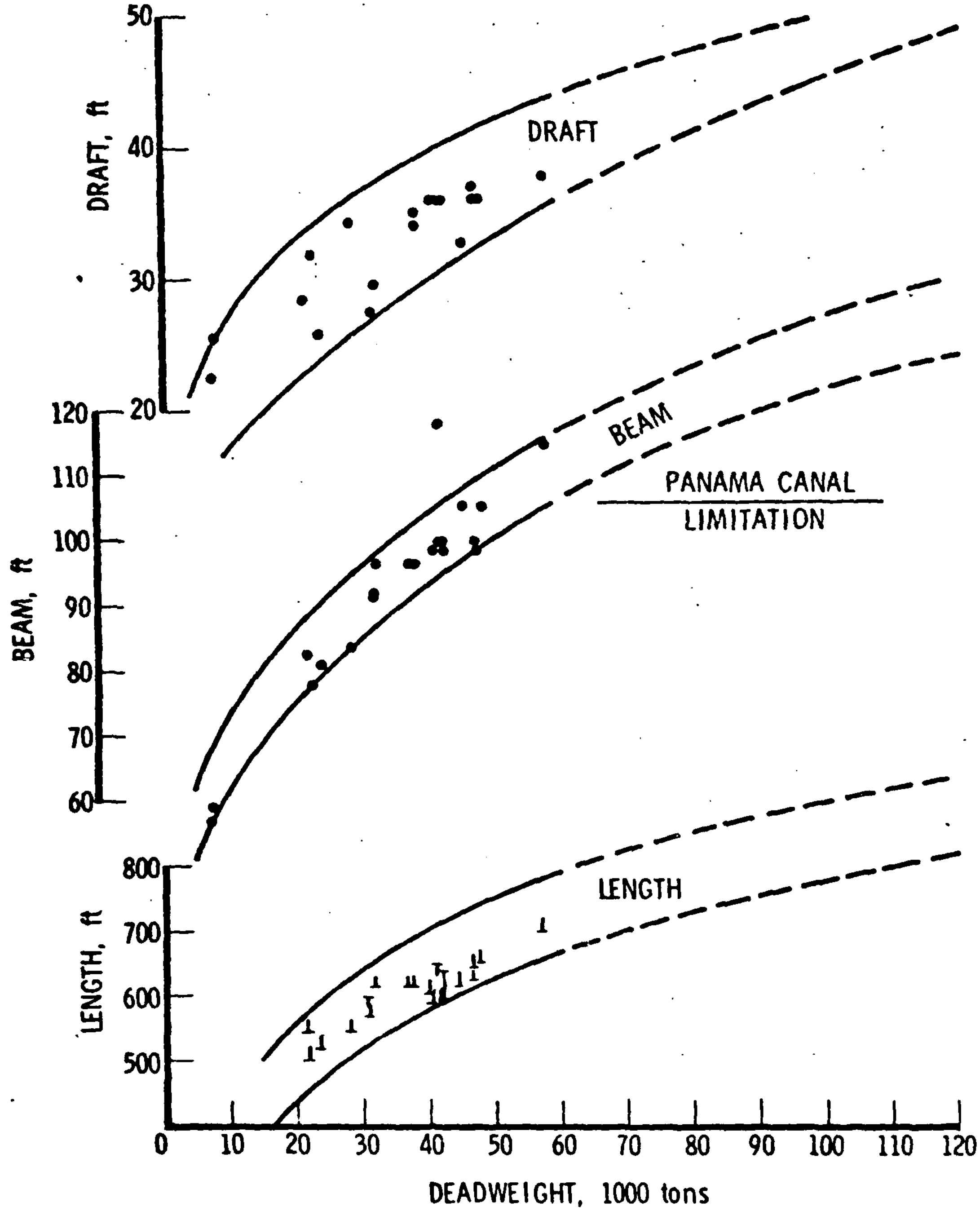


Figure 6
Length, Beam, and draft of Woodchip Carriers on Order in 1974

Source: Port System Study, Volume II, Part 5, March 1975, Pages 1-41

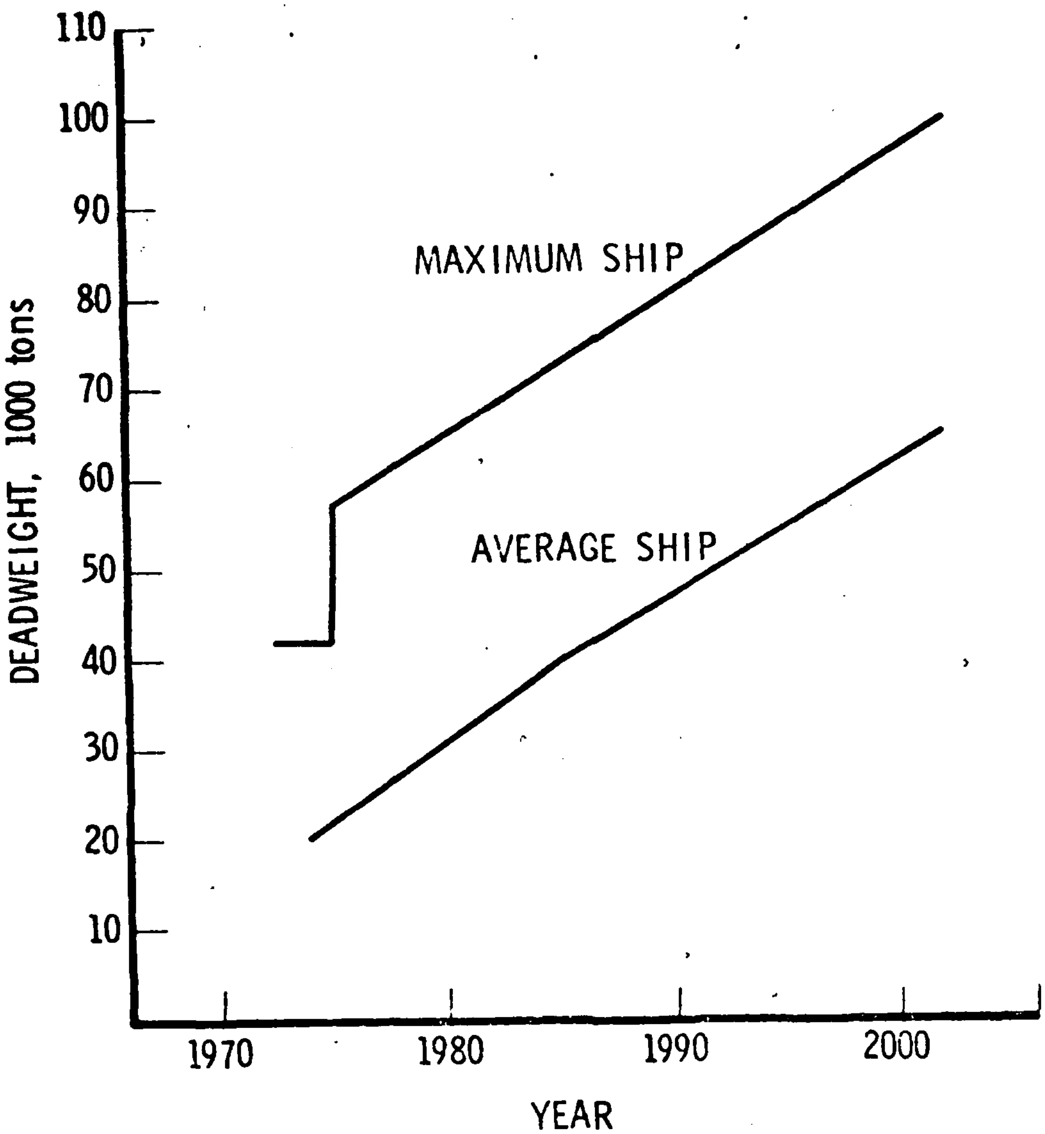


Figure 7
Forecast of Trend in Average and Maximum Size of Woodchip Carriers for Period 1974-2000

Source: Port system Study, Volume II, Part 5, March 1975, Pages 1-42

APPENDIX D

ENGINEERING, DESIGN, AND COST ESTIMATES

GRAYS HARBOR, WASHINGTON

APPENDIX D
ENGINEERING, DESIGN, AND COST ESTIMATES

TABLE OF CONTENTS

TABLE OF CONTENTS (con.)

SECTION 3. COST ESTIMATE AND SCHEDULE

TABLES

TABLE OF CONTENTS (con.)

FIGURES

SECTION 1. DESIGN CONSIDERATIONS

1.01 Hydrology.

a. Climatology. Grays Harbor is typical of temperate coastal embayments with cool, dry, summers and mild, wet winters. Locally, variable winds and precipitation patterns occur due to the influence of the surrounding Willapa Hills and Olympic mountains. Table D1-1 summarizes the general weather conditions found at Hoquiam. Precipitation in the Grays Harbor area averages between 70 to 100 inches per year. Heavy rainfall from November to March accounts for 68 percent of the total annual precipitation. At Aberdeen, low rainfall during July to September totals an average of 9.2 inches or 11 percent of the annual total precipitation. Temperate marine water buffer air temperatures in Grays Harbor which, on the average, range from a January low of 39.7° F to a high of 60.8° F in August.

b. Streamflow Characteristics. The Chehalis, Humptulips, Wishkah, Elk, Johns, and Hoquiam Rivers are the major tributaries to Grays Harbor. Table D1-2 summarizes the drainage basin areas for these rivers. The Chehalis River discharges approximately 80 percent of the freshwater flowing into the estuary. Winter flows generally range from 10,000 to 40,000 cubic feet per second (c.f.s.), with the 100-year floodflow estimated at 77,000 c.f.s. Lower flows occur in the summer and are generally 2,000 to 3,000 c.f.s. with extreme low discharges of 1,000 c.f.s. Grays Harbor is a partially mixed to well mixed estuary, although at times stratification is pronounced in the upper estuary. The saline wedge fluctuates between Hoquiam Reach to above Cosmopolis, depending upon the tidal stage and Chehalis River discharge.

1.02 Tides and Tidal Currents. Offshore of Grays Harbor and beyond the outer bar, the tidal current is generally masked by nontidal currents brought about by winds and alongshore currents. On the outer bar and inside the harbor, tidal currents dominate, except in the upper part of estuary during periods of high-river discharges. The Washington coast is subject to tides of the mixed types, i.e., two unequal high and low waters each day. At Grays Harbor, the mean diurnal ranges are 8.5 feet at the ocean entrance (Westport) and 10.1 feet at Aberdeen. Tidal influences extend to above Montesano, well above the project limits. High and low tides at Aberdeen occur about 1 hour later than at the ocean entrance.

1.03 Tidal datum plane elevations at Westport (approximately equal to ocean tides) and Aberdeen, based on U.S. Coast and Geodetic Survey and National Ocean Survey datums, are shown in table D1-3.

TABLE D1-1. PERCENTAGE FREQUENCY OF HOURS WITH VARIOUS WEATHER PHENOMENA AT HOQUIAM (1949-1958)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Thunderstorm	0.3	0.1		0.1	0.1	*	0.1	0.1	*	0.1	0.1	0.1	0.1
Rain or drizzle	33.2	32.9	26.8	21.4	12.9	21.2	14.2	11.8	13.7	21.6	30.3	36.1	22.9
Freezing rain or drizzle		0.3										0.1	*
Snow or sleet	3.8	2.0	1.3	*							1.0	1.2	0.8
Hail	0.1	0.2	0.2	0.3								0.1	0.1
Hours with precipitation	36.2	34.6	27.7	21.4	12.9	21.2	14.2	11.8	13.7	21.6	31.2	36.9	23.6
Fog	20.2	19.7	12.6	10.0	4.9	7.5	8.5	11.9	14.9	19.5	28.6	26.8	15.4
Smoke or haze	5.2	5.2	3.9	1.0	0.3	*	0.4	1.4	6.1	7.9	9.2	7.6	4.0
Dust or sand													*
Blowing sand													*

*Indicates less than 0.1 percent.
SOURCE: Phillips and Donaldson, 1972

TABLE D1-2

DRAINAGE BASIN AREAS OF
RIVERS TRIBUTARY TO GRAYS HARBOR

Freshwater Source	Location of Confluence with Grays Harbor	Drainage Area (sq. miles)
Chehalis River	Above the Wishkah River at Aberdeen, Washington	2,012
Wishkah River	At mouth, U.S. Highway 410 at Aberdeen, Washington	102
Hoquiam River	At mouth, U.S. Highway 101 at Hoquiam, Washington	90.2
Humptulips River	Near Mouth, at State Highway 9C in North Bay	245
John's River	At mouth, south end of South Bay	18.2
Miscellaneous Tributaries		51.4
	TOTAL	2,518.8

Reference: Beverage and Swecker, 1969.

TABLE D1-3

TIDAL DATUM PLANES

Datum Plane	Elevation in Feet Referred To MLLW	
	Westport	Aberdeen
Highest Tide (Estimated)	14.00	14.90
Mean Higher High Water	8.70	10.10
Mean High Water	8.20	9.40
Mean (Half) Tide Level	4.80	5.45
Mean Sea Level	4.60	5.38
Mean Low Water	1.40	1.50
Mean Lower Low Water	0.00	0.00
Lowest Tide (Estimated)	- 3.50	- 2.90

High wind conditions can alter tidal patterns significantly. Strong offshore or onshore wind transport of large volumes of water can inhibit the magnitude and duration of both high- and low-water occurrences. High freshwater discharge will also affect tides in the upper estuary, especially lower tides.

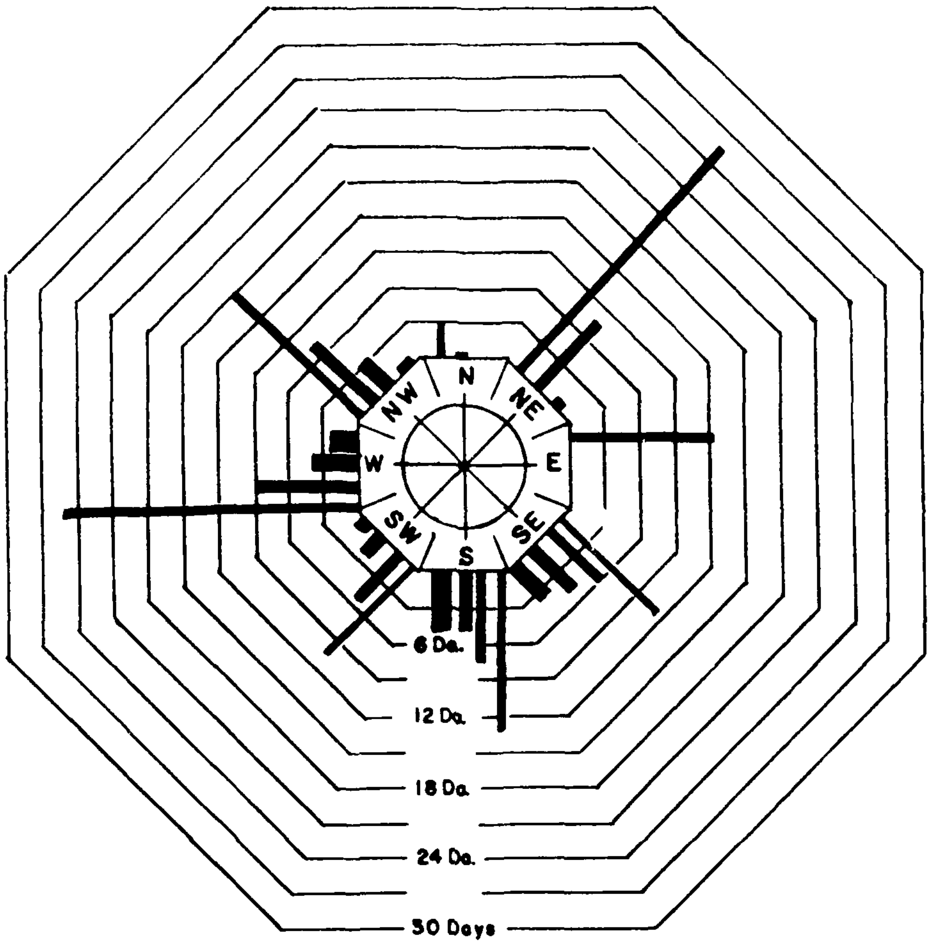
1.04 Winds. Wind data from several sources are available in the Grays Harbor area, including U.S. Coast Guard (USCG), Federal Aviation Administration, and the U.S. Army Corps of Engineers.

1.05 The seasonal cycle of winds over the northeast Pacific Ocean is largely determined by the circulation about the North Pacific high pressure area and the Aleutian low pressure area. During the summer months, the high reaches its greatest development. In July the center of highest pressure is located near latitude 30° N, longitude 150° W. During this period, the Aleutian low is almost nonexistent. This pressure distribution causes predominantly northwest and north winds over the coastal and near offshore areas of Oregon and Washington. The high weakens with the approach of the winter season and by November is usually little more than a weak belt of high pressure lying between the Aleutian low and the equatorial belt of low pressure. These traveling depressions moving eastward cause considerable day-to-day variation in pressure, particularly in the area north of latitude 40° N. The winter winds are frequently of gale force (5 to 8 percent of the observations) and range in direction from southeast at the coast to southwest in the offshore region. Annual wind rose and maximum wind velocity duration curves for Westport (figures D1-1 and D1-2) show that the strongest winds are out of the south to west in Grays Harbor. Winds at Hoquiam have a more east-west component than the coastal station, probably due to the orientation of the Chehalis River Valley.

1.06 Waves.

a. Ocean Sea and Swell. Under contract to the Corps of Engineers, National Marine Consultants, Inc. (NMC) performed a wave study in 1961 in which they analyzed 3 years of synoptic weather data for all of the Pacific and hindcast the resultant sea and swell waves that approached the Washington and Oregon coast. Weather data from the years 1956, 1957, and 1958 were utilized to determine occurrences of waves by direction, period, and deepwater significant wave height (average of the one-third highest waves of a wave group). These years were significantly different from one another in terms of storm frequency, but the mean wave characteristics are representative of an "average" year. Sea and swell data for deepwater station 2, located 30 miles west of the Columbia River, is shown on figures D1-3 and D1-4. The following summary of deep water wave conditions off the coast of Grays Harbor is based on the wave statistics of NMC:

(1) The longest period and highest waves occur in winter with predominant swell from the south-southwest to the west-northwest and



LEGEND

VELOCITY RANGE in MPH

10 TO 15
15 TO 20
20 TO 25
OVER 25

NOTE: Based on incomplete and intermittent records.

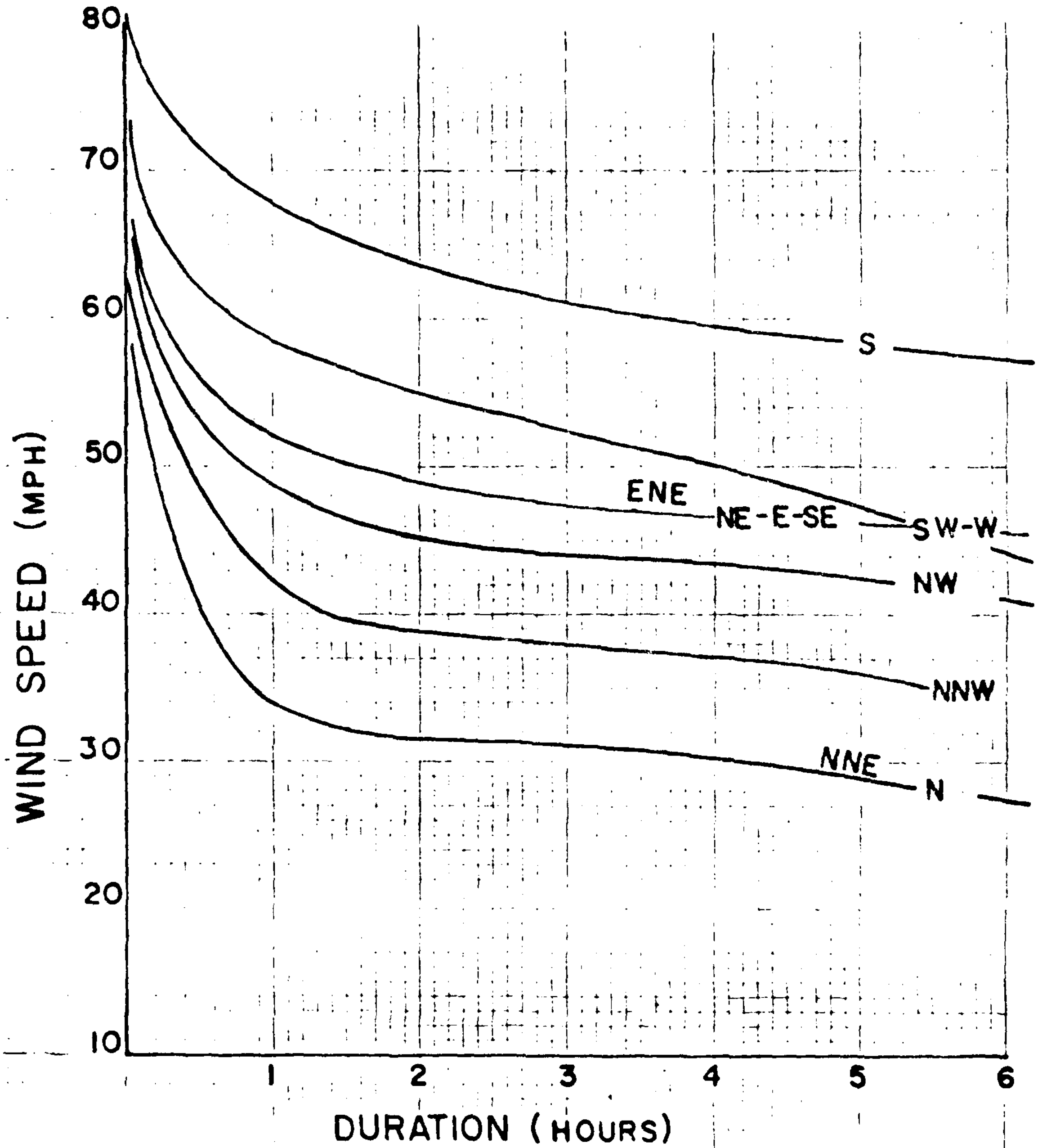
WESTPORT, WASHINGTON
(GRAYS HARBOR)

WIND ROSE

FROM 1953 to 1955

U. S. Army Engr. District Seattle, Wash.
Dr.: Transmitted with report
Tr.: dated 19
Ck.: **E-5-1-67**

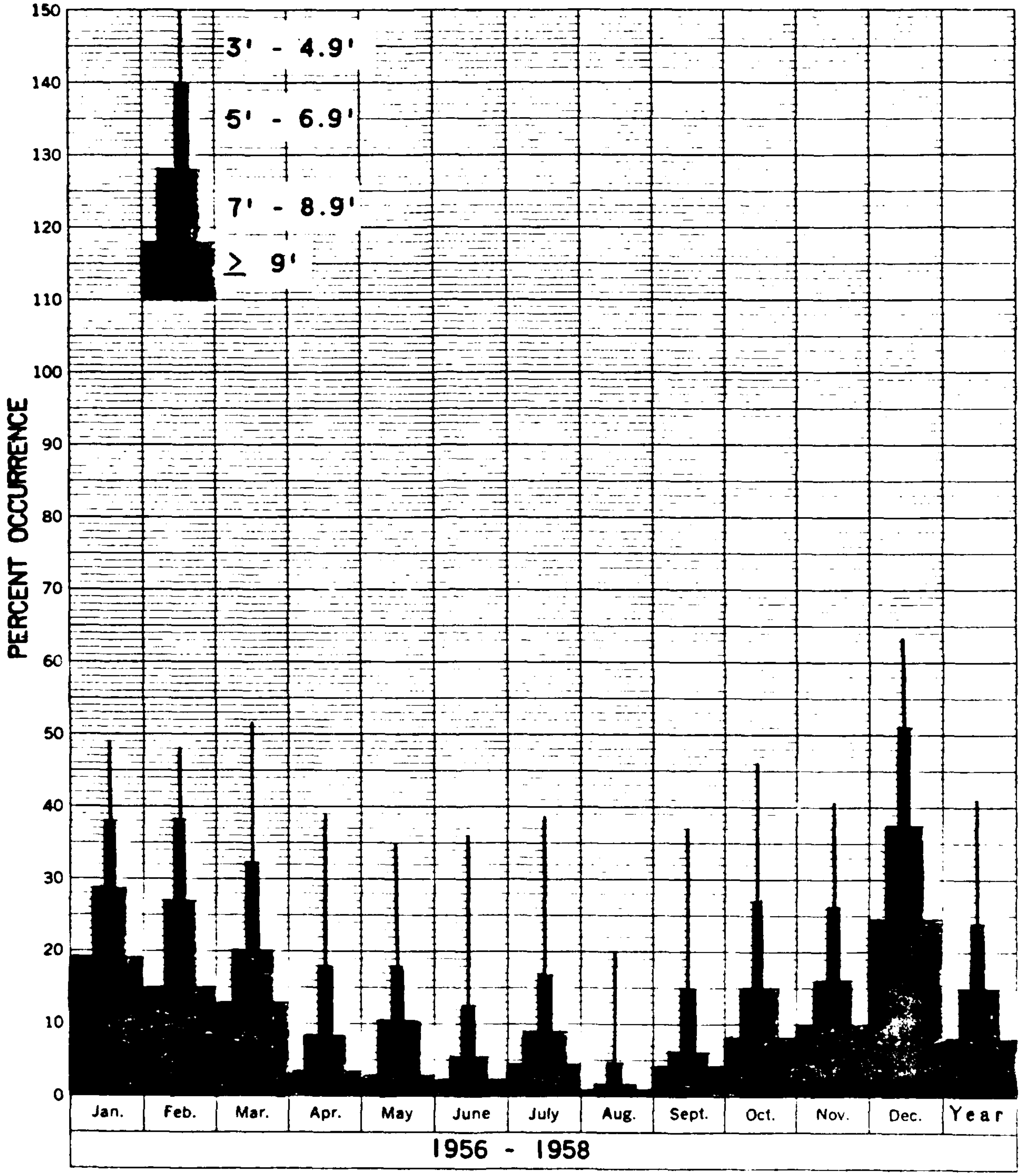
FIGURE D1-1



DATA FROM CORPS OF ENGINEERS WIND RECORDER LOCATED ATOP COAST GUARD LOOKOUT TOWER. RECORD PERIOD 8-4-71 THRU 11-15-73.

WESTPORT HARBOR
WIND VELOCITY
DURATION CURVES

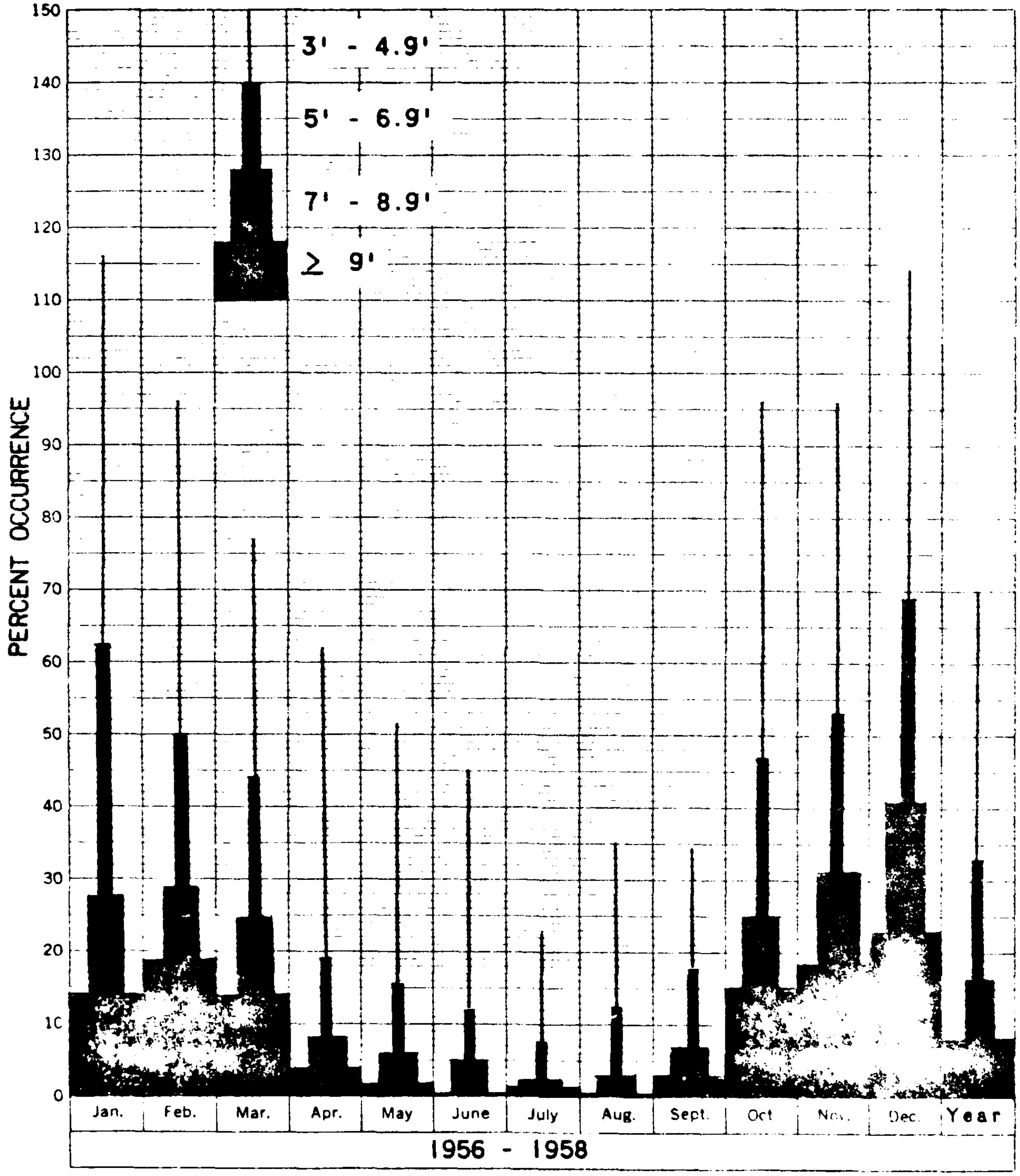
FIGURE D1-2



DEEPWATER SEA DATA

H_s vs. % Occurrence (from N.M.C., May 1961)

FIGURE D1-3



DEEPWATER SWELL DATA

H_S vs. % Occurrence (from N.M.C., May 1961)

FIGURE D1-4

seas from the south-southwest to the south. As shown on figures D1-3 and D1-4, both sea and swell in December and January exceed 9 feet about 20 percent of the time.

(2) The shortest period waves and lowest wave heights occur in summer. Sea and swell during summer exceed 5 feet less than 15 percent of the time and exceed 9 feet less than 5 percent of the time.

(3) Throughout the year, sea and swell greater than 7 feet each occur about 15 percent of the time. The majority of these waves have periods of 8-12 seconds.

Waves of heights over 30 feet can be expected about every year off Grays Harbor. Significant and extreme wave conditions for the Washington coast have been estimated by Quayle and Fulbright using merchant marine visual observations in combination with theoretical hindcast techniques. These are presented for specified return intervals or recurrence intervals of calculated wave heights. The values are presented in table D1-4.

TABLE D1-4

WAVE HEIGHT ESTIMATES FOR SPECIFIED RETURN PERIODS

	5-Year	10-Year	25-Year
Significant Wave Height	39 feet	43 feet	51 feet
Extreme Wave Height	70 feet	79 feet	93 feet

Reference: Quayle and Fulbright

On the outer bar and entrance areas, waves are frequently between 5 and 15 feet in height with maximum waves over 30 feet. The wave climate generally decreases in the entrance area because of wave energy losses on the outer bar and inner shoals and from protection afforded by North and South Jetties. However, the waters will generally be confused, with ocean sea and swell frequently occurring simultaneously and from different directions.

Refraction studies indicate that deepwater waves are refracted toward the entrance to Grays Harbor due to bathymetry off Grays Harbor. The outer bar bathymetry especially affects refraction and concentrates wave energy in the entrance and outer bar channels. A majority (up to 75 percent) of ocean swells approach Grays Harbor in such a direction that they pass between the jetties and into the harbor entrance. Selected refraction diagrams are shown on figures D1-5 through D1-7.

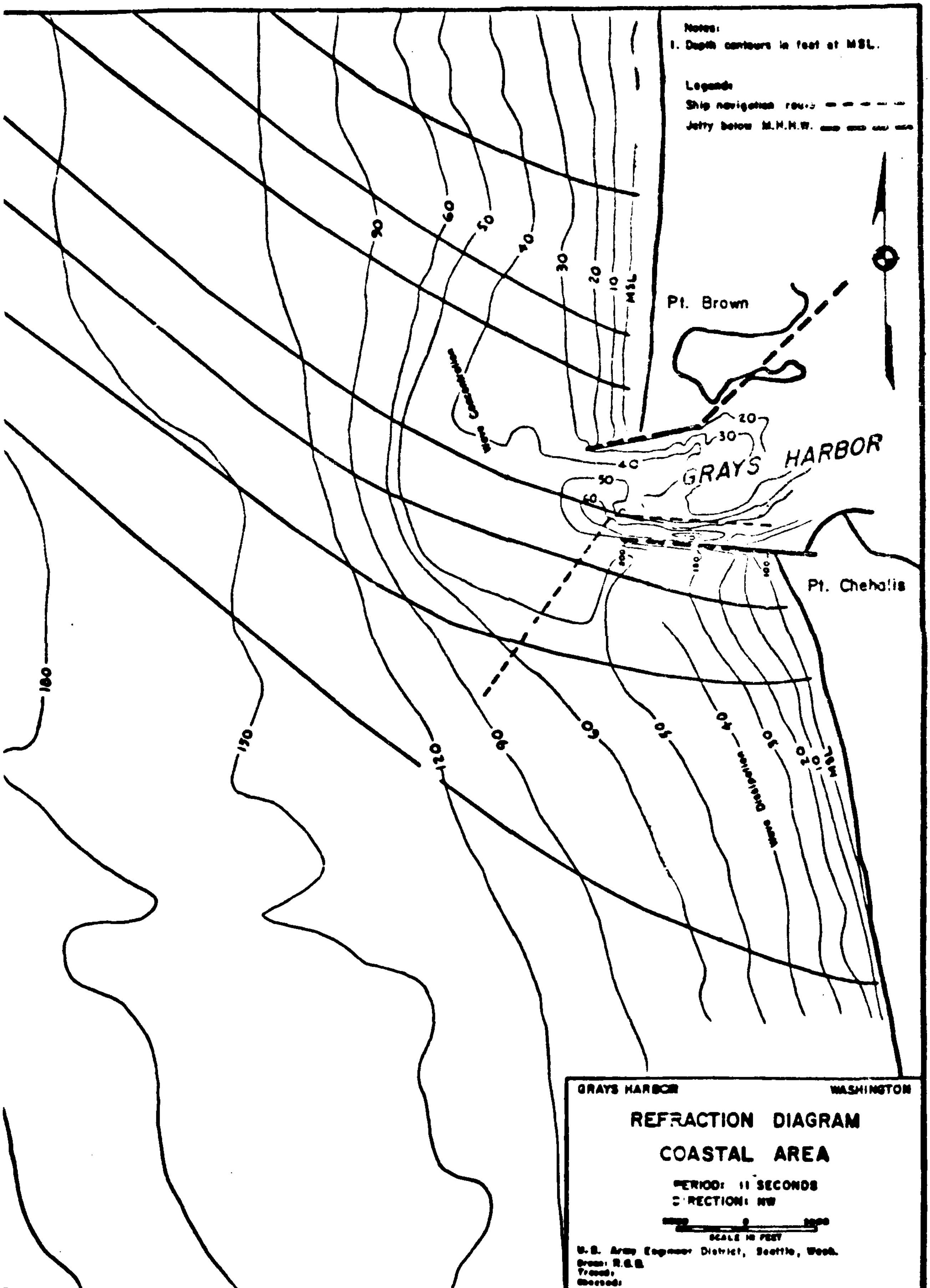

Notes:
1. Depth contours in feet at MSL.
Legend:
Ship navigation route
Jetty below M.H.H.W.
Pt. Brown
GRAYS HARBOR
Pt. Chehalis
Wave Concentration
Wave Dissipation
MSL
10
20
30
40
50
60
90
120
150
180
GRAYS HARBOR
WASHINGTON
REFRACTION DIAGRAM
COASTAL AREA
PERIOD: 11 SECONDS
DIRECTION: NW
SCALE IN FEET
U.S. Army Engineer District, Seattle, Wash.
Drawn: R.S.B.
Traced:
Checked:

FIGURE D1-5

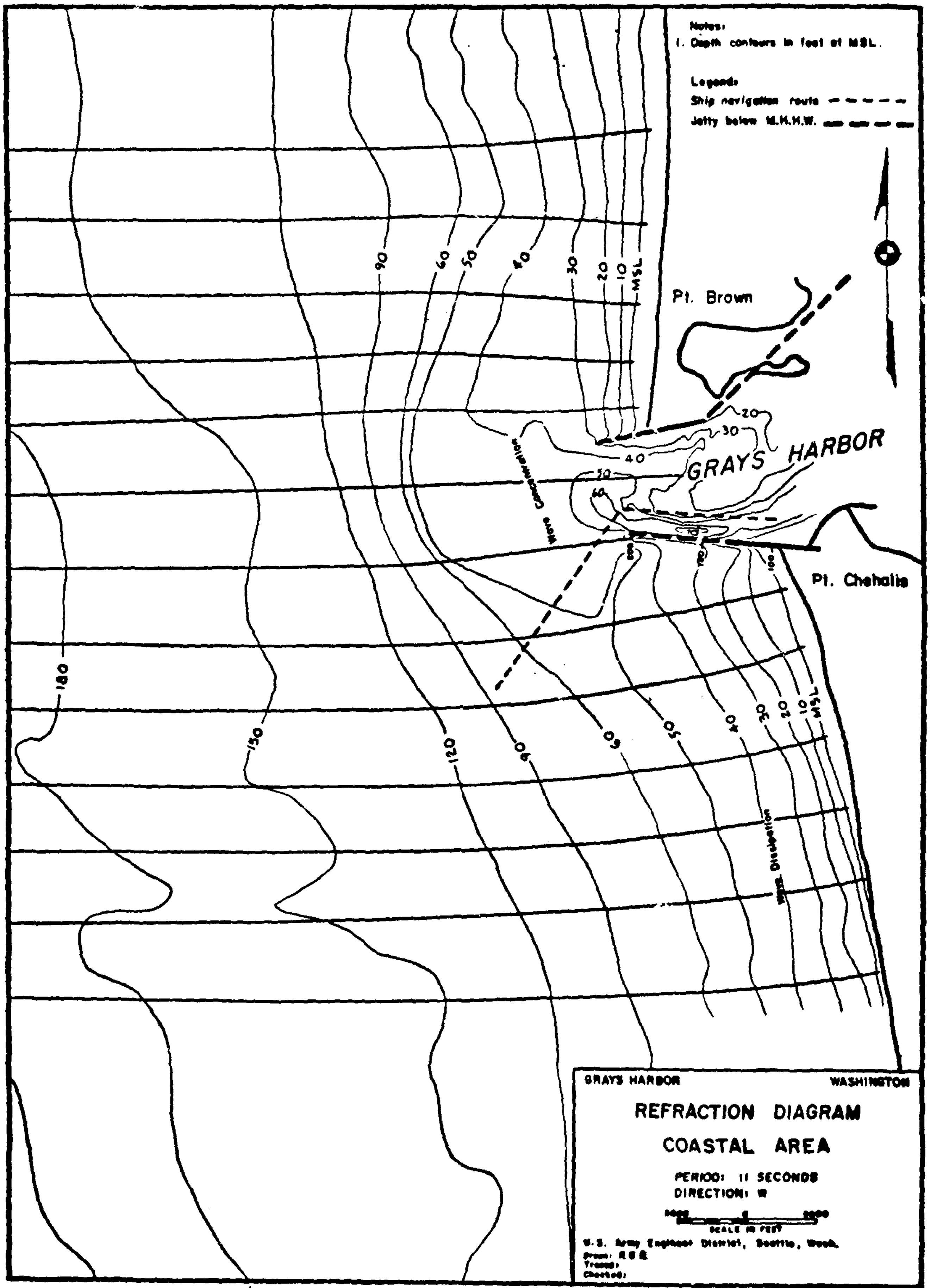
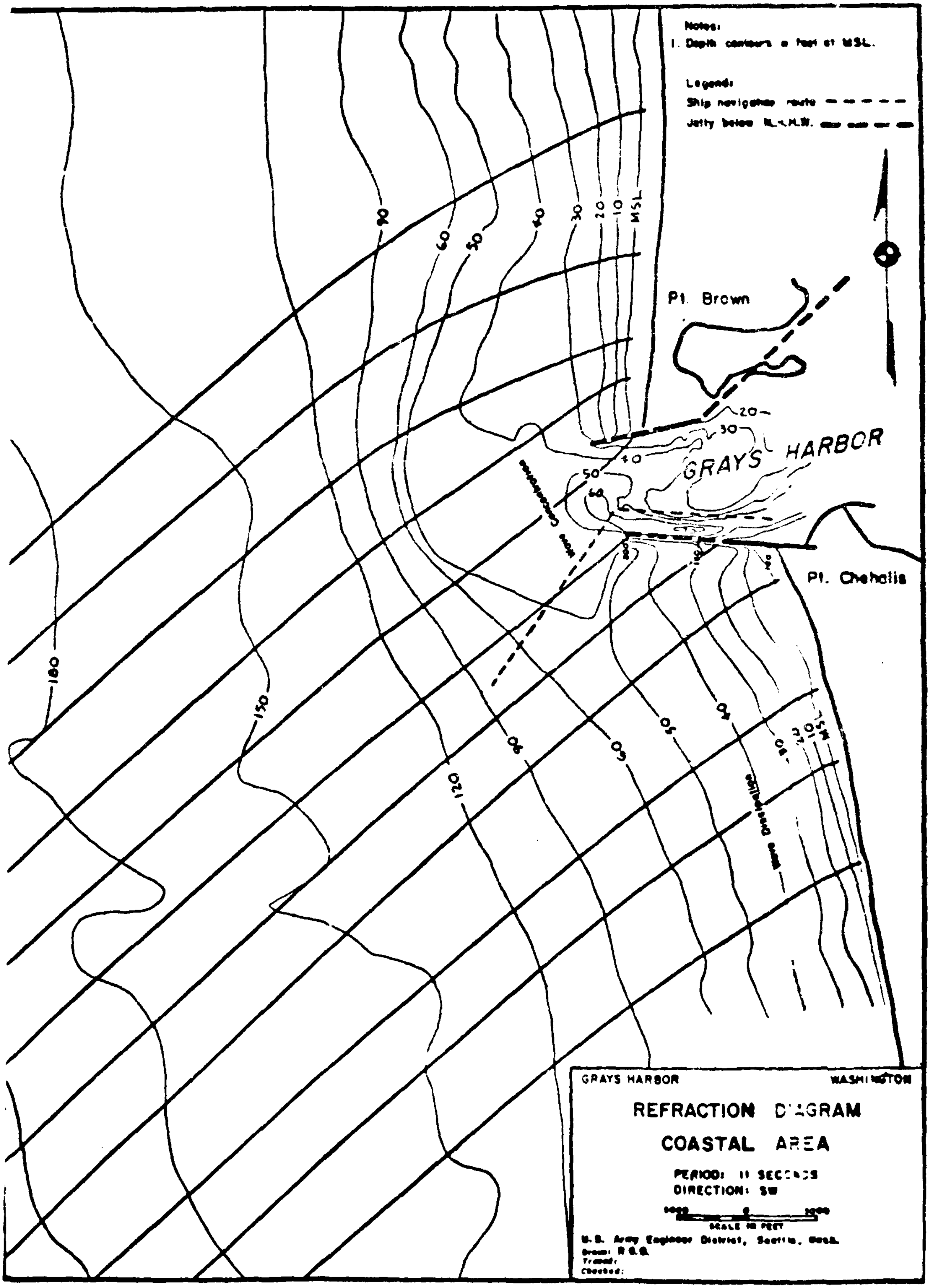

Notes:
1. Depth contours in feet at MSL.
Legend:
Ship navigation route
Jetty below M.H.H.W.
Pt. Brown
GRAYS HARBOR
Pt. Chehalis
Wave Concentration
Wave Dissipation
90
60
50
40
30
20
10
MSL
180
150
120
GRAYS HARBOR
WASHINGTON
REFRACTION DIAGRAM
COASTAL AREA
PERIOD: 11 SECONDS
DIRECTION: W
SCALE IN FEET
U.S. Army Engineer District, Seattle, Wash.

FIGURE D1-6



Notes:
1. Depth contours in feet at MSL.
Legend:
Ship navigation route
Jetty below M.L.H.W.
90
60
50
40
30
20
10
MSL
Pt. Brown
20
30
GRAYS HARBOR
40
50
60
Pt. Chehalis
180
150
120
90
60
50
40
30
20
10
MSL
GRAYS HARBOR
WASHINGTON
REFRACTION DIAGRAM
COASTAL AREA
PERIOD: 11 SECONDS
DIRECTION: SW
SCALE IN FEET
U.S. Army Engineer District, Seattle, Wash.
Drawn: R.G.B.
Traced:
Checked:

FIGURE D1-7

The confused waters are compounded by the action of tidal currents, shoaling of the waves, and reflection off the jetties. During ebb flow, wave steeping on the outer entrance and bar will increase wave heights by up to 25-40 percent based on Columbia River wave gaging data. Wave heights in the vicinity of Point Chehalis are generally less than 5 feet but with maximums of over 10 feet. The natural protection afforded the upper estuary by land features and shoals limit wave heights to about 5 feet in the South Reach area and to about 2 feet in the Moon Island Reach.

As part of the U.S. Army Field Data Collection Program, a wave rider buoy was placed in deep water about 30 miles off Grays Harbor in November 1981. Data from this buoy (height, period and spectrum) will be available for continued planning and engineering (CP&E) studies prior to finalization of project design.

b. Wind Generated Waves. Wind generated waves are common in Grays Harbor and have a pronounced effect on suspension and movement of shallow water sediments. Prevailing and strongest winds are from the west and south, especially during winter. During summer, northerly winds of less intensity frequently occur. Wave heights in the estuary depend on tide stage as much of the estuary is above water during low tide. At high tide, with longer effective fetches, waves in the outer harbor over 5 feet can occur, although 1- to 3-foot-high waves are more common. Upstream of Rennie Island, wind generated waves are limited to less than 2 feet by protection afforded by land masses and short fetch lengths. During periods of strong winds, visual observation of wave generated suspension of shallow water sediments is very evident and extends throughout the entire estuary. The wind generated waves have little effect on deep draft vessels because of the relatively short periods, 2 to 4 seconds, of the waves.

c. Vessel Generated Waves. Vessels plying Grays Harbor consist of recreation craft, commercial fishing boats, tugs and barges, and deep-draft ships. Vessel generated waves affect shallow areas in the Moon Island Reach and upstream through resuspension of material. Downstream of Moon Island Reach, water depths are relatively deep outside the channel and vessel wakes have little effect on shallow areas. Vessel wakes can approach 3 feet for tugs and large fishing boats under high speed. Vessel wakes for deep draft ships will generally be less than 2 feet. Vessel wakes have not been identified as a serious problem for the existing project (traffic is relatively light and operators usually restrict speed in congested areas) and will not be increased by the proposed project. Compared to local wind generated waves, tidal and river currents, the effect of vessel waves on bank erosion and suspension of shallow water materials is considered insignificant.

1.07 Hydraulics. Grays Harbor estuary is roughly "pear-shaped" and is about 11 nautical miles wide and about 15 nautical miles long. The estuary has large expanses of tidal flats and numerous ebb channels

throughout. The surface area varies from about 91 square miles at mean higher high water (MHHW) to about 38 square miles at mean lower low water (MLLW). Diurnal tidal prism volume of the estuary is 1.7×10^{10} feet^3 (O'Brien). The harbor entrance is fixed by two convergent jetties: the North Jetty, 17,200 feet long, and South Jetty, 13,734 feet long, which constrict the entrance width to about 6,500 feet. The North Jetty was reconstructed in 1975 and is in good condition. The inner 4,000 feet of South Jetty was reconstructed in 1965; however, the outer mile of the jetty was not reconstructed and has deteriorated to an elevation of -5 to -20 feet MLLW. With the jetty constriction and diurnal tidal prism volume, spring tide ebb flow discharges are commonly over 1 million c.f.s. across the entrance area. Freshwater from river runoff, primarily the Chehalis River, is mixed with seawater in the Grays Harbor estuary, forms a low-salinity, low-density, upper layer which tends to move seaward. Deeper seawater tends to move toward the head of the estuary or river mouth along the bottom as high density currents. In the estuary, vertical mixing is rapid and directly involves river water of negligible salt content and seawater of high salinity. In moving seaward, however, the upper layers are continuously increasing in salt content, the salinity tending to approach that of the underlying water. The estuary is generally well mixed in the outer harbor and partially mixed in the upper harbor where at times stratification is pronounced.

1.08 The North and South Jetties have a pronounced effect on tidal flows from Point Chehalis out across the bar. The ebb current movement of water out of North Bay has a southerly movement component to along the southern half of the entrance channel and has scoured a deep channel from Point Chehalis seaward along the South Jetty and across the bar. Since construction of the jetties, circa 1900's, ebb flow has scoured the southern 2,000 feet of the entrance channel to depths of over 70 feet (undermining the South Jetty and requiring the previously mentioned partial reconstruction in 1965) and has scoured the outer bar from depths of about 15 feet to over 35 feet MLLW. The ebb flow effect extends seaward some 3 miles carrying bar material offshore and 1981 condition surveys show the bar extends about 13,000 feet seaward of South Jetty in a convex seaward shape. Incoming flood flows on the outer bar are much weaker than the concentrated ebb flows (typical flood tide currents are 1 foot per second (f.p.s.) whereas ebb currents are 3 to 4 f.p.s.) and not until inside the jetties do flood tide currents become significant. Flood currents are stronger along North Jetty compared to along South Jetty, while the reverse is true for ebb tide currents. This tidal current phenomenon is an important factor to outer harbor and offshore sedimentation processes. Figures D1-8 through D1-11 are schematics which show the current velocity and pattern from the entrance area across the outer bar. Data is based on several drogue studies (on file Seattle District) of the shallow and deep currents of the estuary for the period 1975-1981, U.S. Army Engineer, Waterways Experiment Station (WES) model studies, and field measurements by the U.S. Coast and Geodetic Survey.

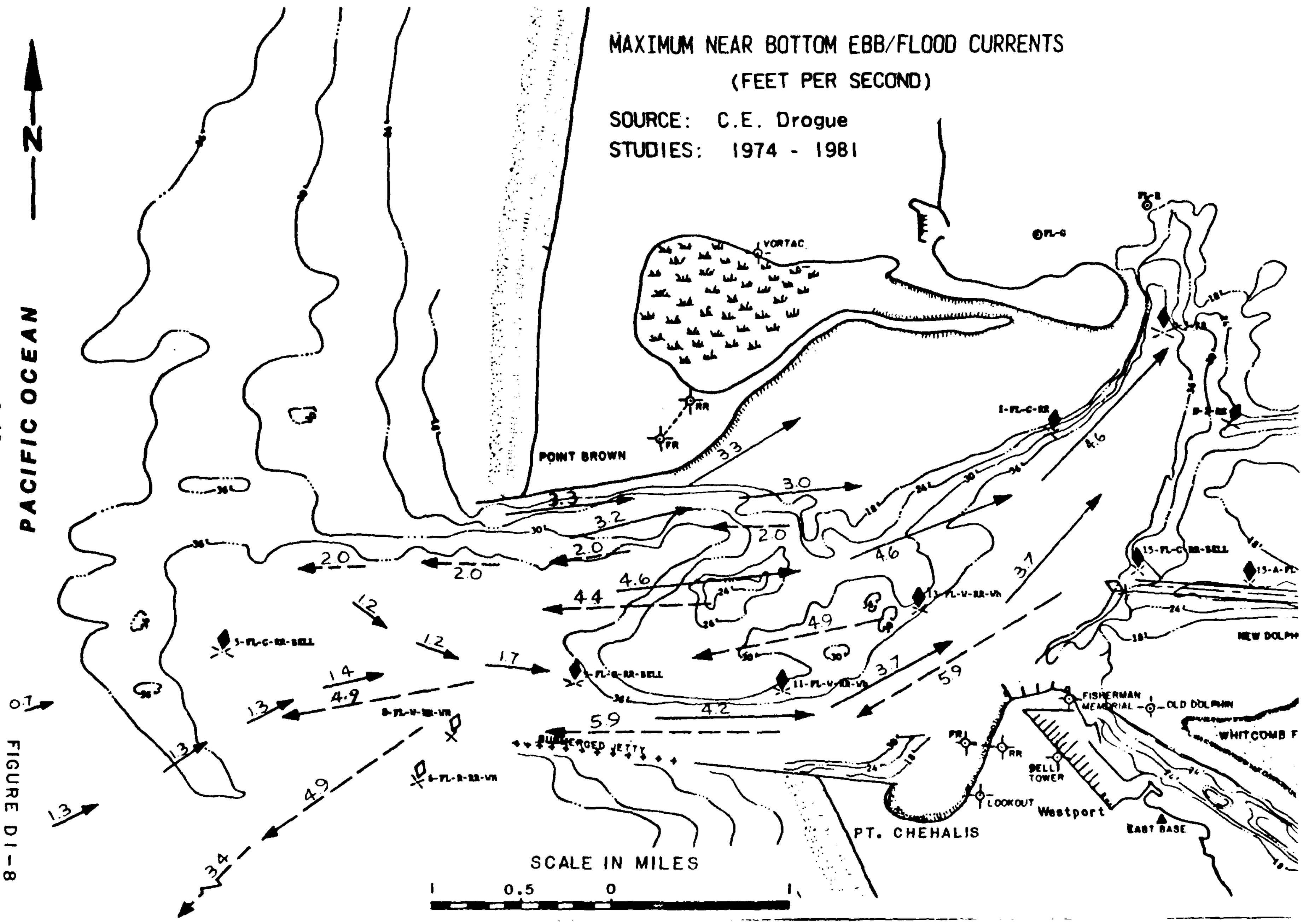

MAXIMUM NEAR BOTTOM EBB/FLOOD CURRENTS
(FEET PER SECOND)
SOURCE: C.E. Drogue
STUDIES: 1974 - 1981
N
PACIFIC OCEAN
POINT BROWN
VORTAC
PT. CHEHALIS
Westport
FISHERMAN MEMORIAL
OLD DOLPHIN
BELL TOWER
LOOKOUT
EAST BASE
SUBMERGED JETTY
SCALE IN MILES
1
0.5
0
1

FIGURE DI-8

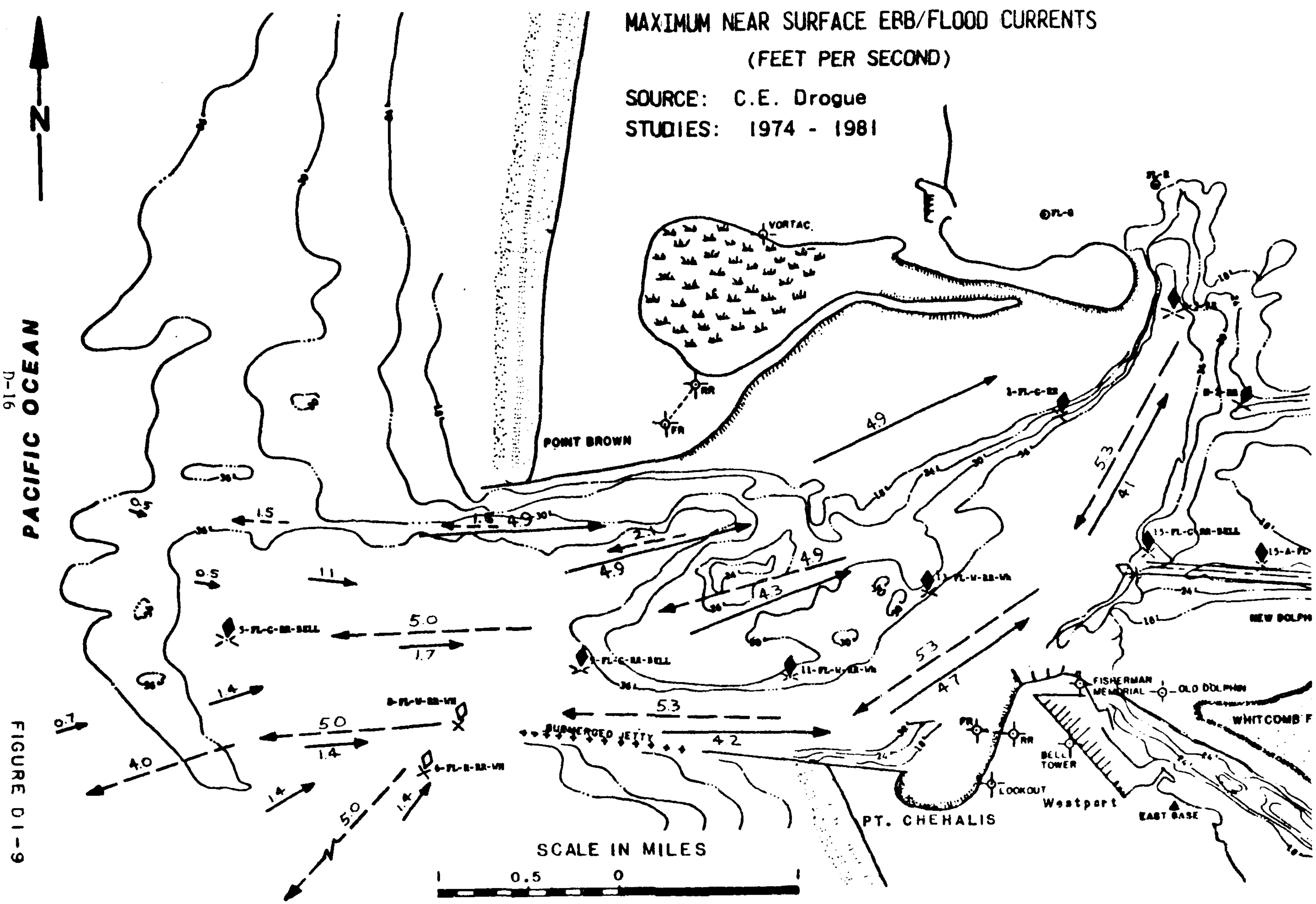
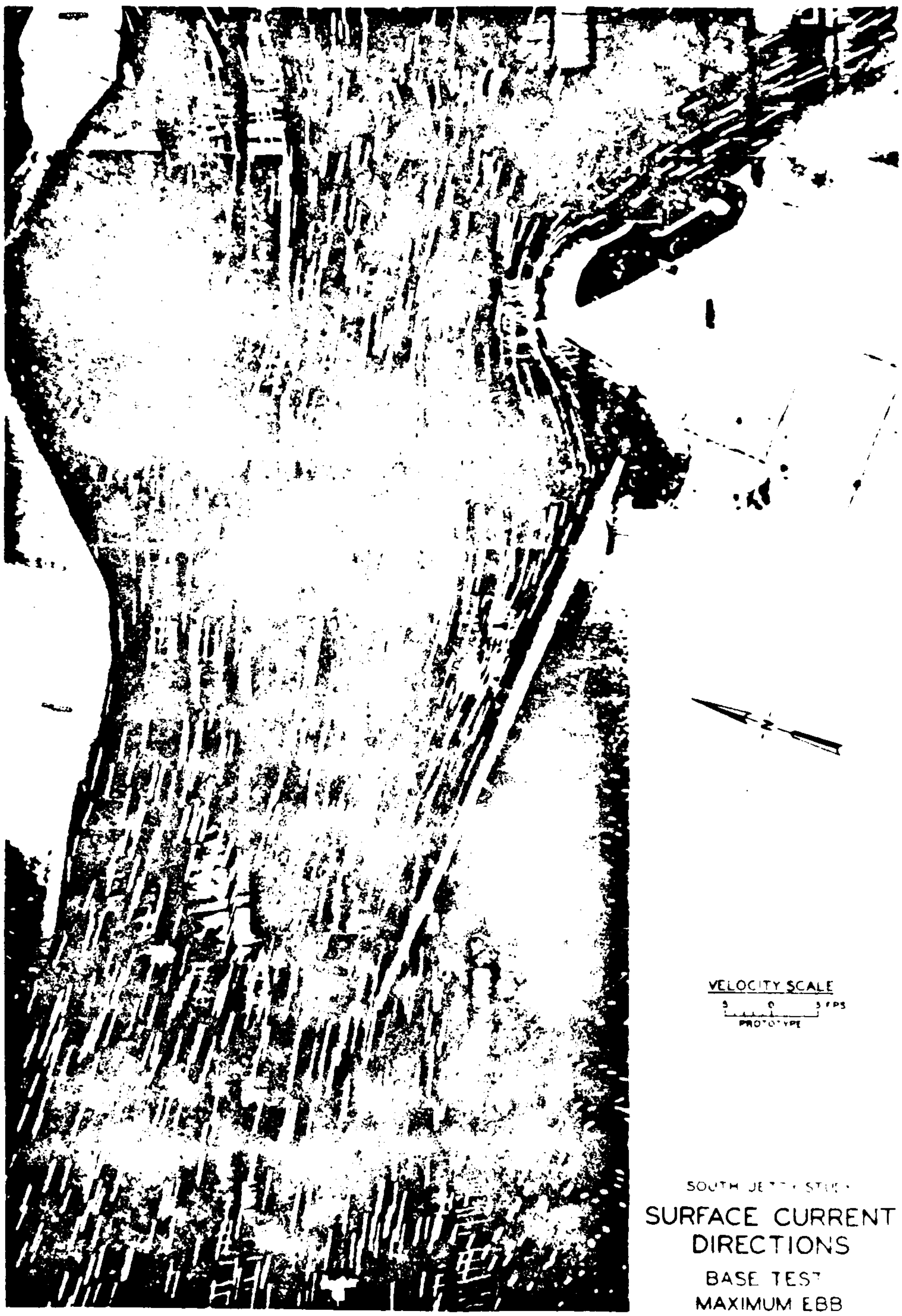

MAXIMUM NEAR SURFACE EBB/FLOOD CURRENTS
(FEET PER SECOND)
SOURCE: C.E. Drogue
STUDIES: 1974 - 1981
N
PACIFIC OCEAN
POINT BROWN
VORTAC
RR
FR
PT. CHEHALIS
Westport
LOOKOUT
BELL TOWER
FISHERMAN MEMORIAL
OLD DOLPHIN
EAST BASE
NEW DOLPH
WHITCOMB F
SUBMERGED JETTY
SCALE IN MILES
1
0.5
0
1

FIGURE DI-9



SOUTH JETTY STUDY
SURFACE CURRENT DIRECTIONS
BASE TEST
MAXIMUM EBB
HOUR 17

☆ U S GOVERNMENT PRINTING OFFICE 1976—796 361

FIGURE D1-10

SOUTH JETTY STUDY

SURFACE CURRENT DIRECTIONS

BASE TEST

MAXIMUM FLOOD

HOUR 23

☆U S GOVERNMENT PRINTING OFFICE 1976—790-301

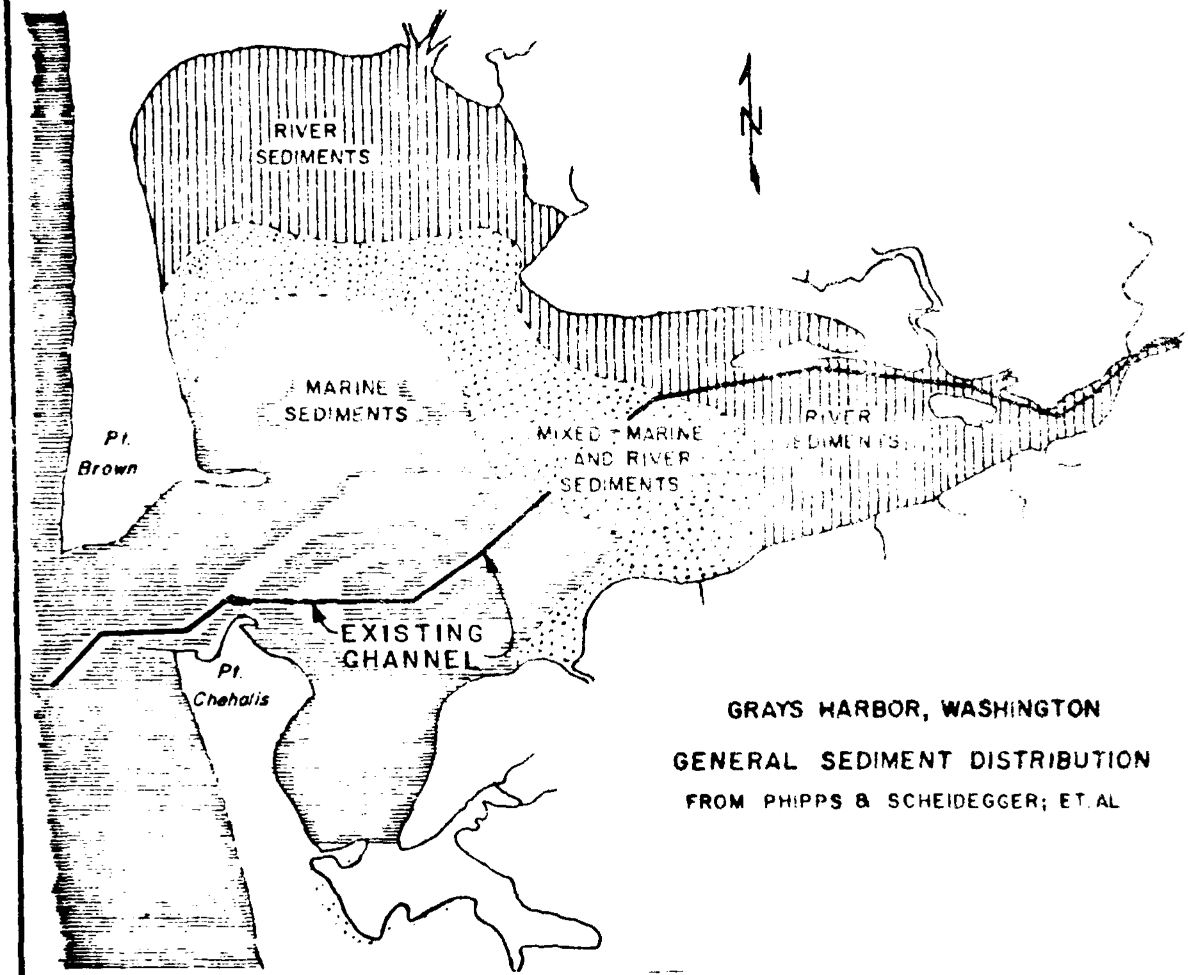
FIGURE D1-11

1.09 Currents in the upper estuary are generally about 3 f.p.s. on both ebb and flood flows, with maximums to about 5 f.p.s. Currents are generally in alinement with the channel, except some crosscurrents which occur at channel bends. In the central portion of the estuary, outer Moon Island through South Reach, crosscurrents of up to 45 degrees to the channel alinement occur during both ebb and floodflows. Details of currents at various tide phases, freshwater discharges, ocean salinity, etc. are found in the series of WES model reports.

1.10 Sedimentation. Sediment sources to the estuary are from the marine environment and upland river discharge. Natural sedimentation processes have been significantly altered by dredging and construction of the jetty system.

a. Marine. Wave energy studies, littoral drift calculations, and sediment analysis indicate the net movement of nearshore sediment is northward along the Grays Harbor area of the Washington coast. Variations in wave climate induce a seasonal change in predominant littoral drift from northerly in the winter to southerly in the summer. Winter storm waves transport Columbia River and Willapa Harbor sediment northward to Grays Harbor ocean beaches. In the summer, material is transported southward from northern rivers, coastal cliffs and from a return of the Columbia and Willapa sediments which have bypassed the Grays Harbor entrance. This general conclusion is also evidenced by longshore wave energy studies, north-trending spits and bars along the coast, and identification of the Columbia River sands through heavy mineral analysis. The nearshore and beach sediment on North and South Beaches and offshore to about 100 feet of water consists of well-sorted fine to medium sands. Alluvial sediments from Grays Harbor rivers are predominantly silts and clay and are deposited in the estuary or carried to the ocean where they are distributed to areas offshore or carried in suspension to the surf zone. Columbia River alluvial sediments are also transported to the ocean waters off Grays Harbor during winter. General sediment regime of Grays Harbor estuary from Phipps and Scheidegger (1974) is shown in figure D1-12.

The net littoral drift at Grays Harbor is calculated to be northerly, with northward transport nearly twice the southern volume. Majority of the northerly transport along the beaches at Grays Harbor is produced by storm waves from the south and southwest. Outer bar waves will often break and undergo significant refraction prior to entering the estuary or impinging on North and South Beaches. The North Jetty provides wave protection to all of the entrance area from northwest waves; whereas, the South Jetty provides little wave protection to the north half of the entrance area from southwest waves. Tidal currents and wave action over the bar produce considerable sediment movement. Wave refraction on the offshore bar is an important consideration of the littoral forces at work at the mouth of the estuary. Southwesterly storms, which generate waves that approach most of the shoreline obliquely from the southwest, have a dominant influence along this part of the coast. The refraction



GRAYS HARBOR, WASHINGTON

GENERAL SEDIMENT DISTRIBUTION

FROM PHIPPS & SCHEIDEGGER; ET. AL

U.S. GOVERNMENT PRINTING OFFICE 1976-796-361

FIGURE D1-12

of the dominant southwest waves on the outer bar also causes waves to approach North Beach nearly perpendicular or even with a southerly component, resulting in a localized southerly littoral drift on the north side of the harbor entrance, and serves to promote accumulation of sand to such an extent that North Beach builds seaward. Sand transport into Grays Harbor occurs during onshore wave attack and flood tide, creating the inner bar shoal between the jetties and contributing to filling of parts of the estuary and shoaling of South Reach and Crossover Channels. The inner bar shoal migrates to the south, restricting the deepwater portion of the entrance channel to near the South Jetty.

The highest energy waves occur during winter and are generally from the west to southwest. The South Jetty provides significant protection to the inner estuary from the southwest waves; however, the northern half of the entrance area is severely attacked by the west to southwest waves. The northern half of the entrance area is also much shallower than the southern half and, as discussed above, sediment movement is very extensive landward. Hydraulic model tests, confirmed by field current measurements and sedimentation patterns, show that flood/ebb currents are stronger/weaker for the northern half of the entrance area compared to the southern half, and thus, a landward movement of sediments occurs in the northern half of the entrance channel, and a seaward movement occurs in the southern half. The general pattern of sediment transport, as discussed above, is evidenced by a number of historical erosion/shoaling patterns available in Grays Harbor. Foremost of these are aerial photograph sequences from 1941 to the present which show migration of Damon Spit and growth of new spits along the North Jetty. These changes are shown on figure D1-13 (aerial photos available in Seattle District). The volume of marine sediments entering Grays Harbor along this route could range on the order of 1 to 2 million cubic yards (c.y.) per year. This material is believed to generally follow a movement pattern along the North Jetty, onto and past Damon Spit, and into North Bay. Once inside the shallow waters of North Bay, the sediments are easily set in motion by local wind generated waves or ocean waves (although much of the ocean wave energy has been lost through shoaling, bottom friction, and refraction) to again be transported by tidal currents or resuspended by wave action. During winter months, when local wind generated waves and ocean waves are highest, the amount of sediment movement is greatest, and during this time, shoaling of South Reach and Crossover Reach channels is greatest.

The ebb current movement of water out of North Bay has a southerly movement component to along the southern half of the entrance channel. These strong ebb flows have scoured the deep channel from Point Chehalis seaward along the South Jetty to depths of over 70 feet. Because this area is also in waters much deeper than the northern half of the entrance it is an area where wave action has much less effect on sediment resuspension (also coupled with wave protection afforded by the jetty) and where ebb tide currents are strongest in a seaward direction. Net movement of sediment is from Point Chehalis seaward along the deep thalweg along

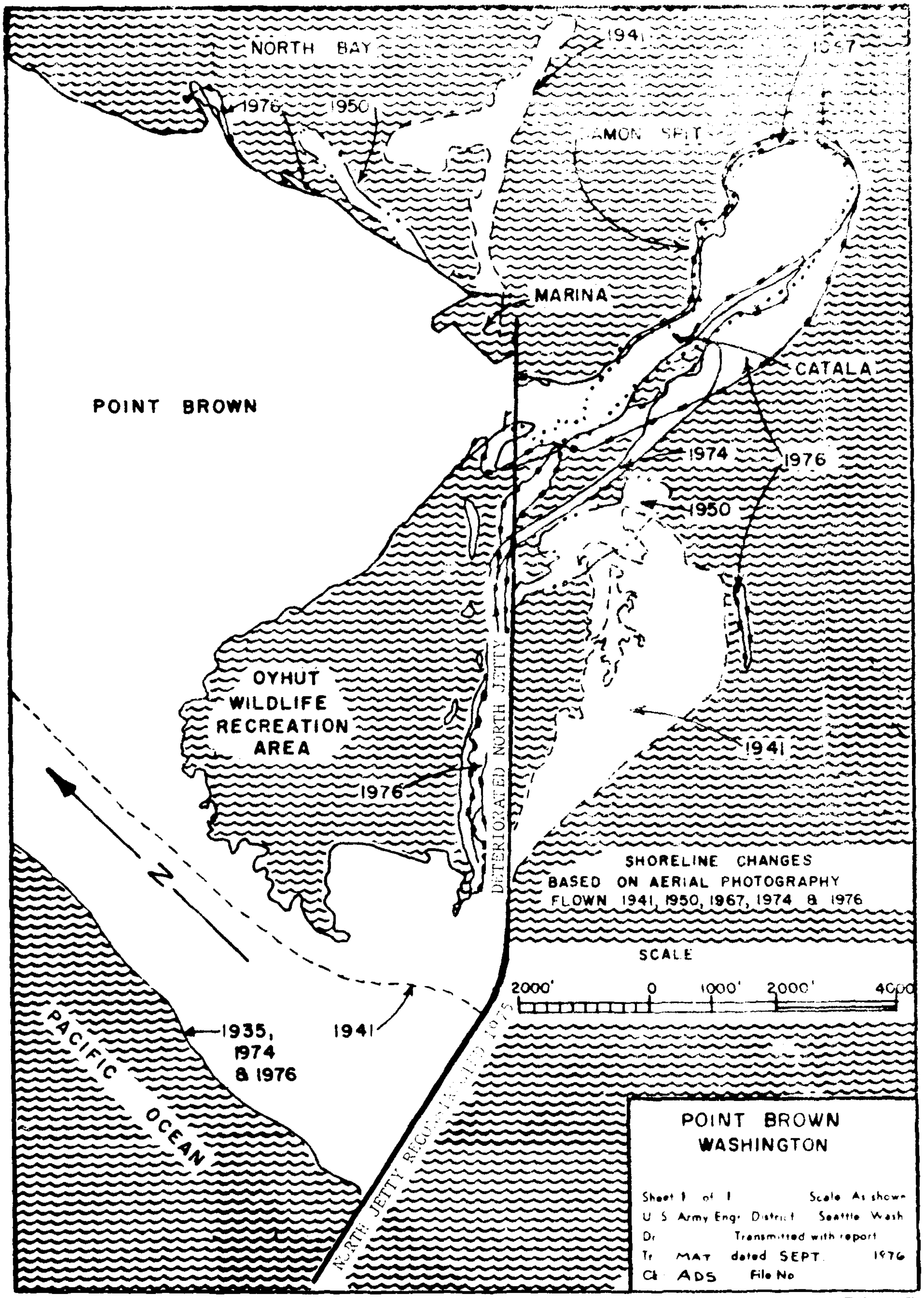

NORTH BAY
1941
1967
1976
1950
DAMON SPIT
MARINA
CATALA
POINT BROWN
1974
1976
1950
OYHUT
WILDLIFE
RECREATION
AREA
1941
1976
DETERIORATED NORTH JETTY
SHORELINE CHANGES
BASED ON AERIAL PHOTOGRAPHY
FLOWN 1941, 1950, 1967, 1974 & 1976
SCALE
2000' 0 1000' 2000' 4000
N
1941
1935,
1974
& 1976
PACIFIC OCEAN
NORTH JETTY RECONSTRUCTED 1975
POINT BROWN
WASHINGTON
Sheet 1 of 1 Scale As shown
U.S. Army Engr District Seattle Wash
Dr Transmitted with report
Tr MAT dated SEPT. 1976
Ck ADS File No

FIGURE D1-13

South Jetty and thence onto the outer bar area where it will again enter the longshore drift system or be deposited in deepwater seaward of the bar. Off Point Chehalis, disposal of dredged material takes place each year, ranging from about 1.5 to 2.5 million c.y. per year at the existing disposal site since 1976. This disposal has resulted in little appreciable build-up of the bottom bathymetry in this area. The existing disposal site and proposed new sites are shown on plate 3 of the feasibility report.

b. River. The sediment transport of the Chehalis River into Grays Harbor is estimated between 1 and 2 million c.y. per year. The Meyer-Peter-Muller (1948) bedload formula, suspended sediment data collected by the U.S. Geological Survey (USGS) (Glancy, 1969), and average daily hydrographs from 1960 to 1967 for the Chehalis River basin were used to calculate the Chehalis River sediment load. In a study by Norman Associates (1974), annual suspended sediment loads from river sources were estimated to average over 1 million c.y., chiefly from upstream erosion. Norman Associates estimate approximately 85 percent of the suspended sediments is due to erosion of upland areas during periods of heavy precipitation. The remaining 15 percent is due to riverbank erosion. Including bedload, the average annual total load is almost 1.5 million c.y. Annual loads for each river basin are shown in table D1-5.

TABLE D1-5

AVERAGE ANNUAL SUSPENDED SEDIMENT AND BEDLOAD FOR RIVERS ENTERING GRAYS HARBOR ESTUARY
(Values in Cubic Yards Per Year)

	Suspended load	Bedload
Chehalis Basin		
Wynoochee River	210,000	90,000
Satsop River	300,000	130,000
Cloquallum Creek	15,000	20,000
Chehalis at Porter	160,000	70,000
Wishkah Basin	40,000	15,000
Hoquiam Basin	45,000	20,000
Humptulips Basin	250,000	110,000
TOTAL	1,020,000	455,000

SOURCE: Norman Associates (1974). Effects of Wynoochee Dam construction in 1972 not included.

c. Ocean. A third, distinguishable sedimentation consideration of the project is the deeper ocean areas offshore of Grays Harbor. Ocean disposal of dredged material is planned although selection of a specific site(s) will not be made until the CP&E study phase. For study purposes, two sites have been selected at this time, each in about 100 feet

of water and in southwest and west directions about 3-1/2 miles offshore of the entrance (see feasibility report). Bottom materials at these sites are a mixture of about 50 percent fine-to-medium sands and 50 percent silts. These sediments (or dredge material disposed at these areas) are subject to movement and transport by ocean bottom currents and wave induced oscillatory flow. Detailed studies of sediment movement off Grays Harbor have not been made; however, data from large-scale ocean circulations off the coast, recent studies off Coos Bay and Columbia River (Oregon State University and Sternberg, et al.), and Corps of Engineers drifter studies provide general insight on sediment processes. These studies are summarized in detail in Corps of Engineers supplemental studies "Technical Support Report, Tidal Hydraulics and Oceanography," February 1982, on file in Seattle District. Summary of conclusions from these studies is as follows:

(1) The major influencing factors controlling ocean currents is on the Washington continental shelf near Grays Harbor are wind direction, velocity, and duration.

(2) Ocean surface and near surface currents near Grays Harbor are directly related to wind direction and velocity. Midwater and bottom currents are indirectly related to surface wind conditions, and their directions and velocity are often different from those of overlying surface currents.

(3) Ocean surface flow is to the south during summer and to the north during winter in response to local winds. At the coast, Ekman dynamics cause offshore surface flow and onshore bottom flow (upwelling) during summer and onshore surface flow and offshore bottom flow (downwelling) during winter.

(4) During summer on the Washington coast, the mean surface current is southwest. The mean bottom current is southeast. When winds are light, a north bottom flow may develop.

(5) During winter, mean surface ocean current is northeast. Mean bottom currents in deep water (greater than 165 feet) flow northwest. When winds are light, a weak deepwater, southward bottom current may develop. Driven by surface waves, onshore bottom waterflow to the northeast occurs in water depths of less than 165 feet. Very near shore (less than 60 feet), however, bottom currents flow northwest (offshore) during storm events.

(6) Observed ocean surface and bottom water velocities are normally less than 1.0 f.p.s. Currents are, however, intensified by storm events where orbital motion of water particles due to passage of large waves can create to-and-fro motions as high as 8.0 f.p.s. and mean unidirectional currents exceeding 2.3 f.p.s. on the bottom.

(7) Columbia River studies by Sternberg, et al., show that dredge disposal buildups of relatively coarse sands in about 85 feet of water are relatively stable.

(8) Corps drifter return data indicates that direction of sediment movement will vary seasonally, northerly in winter and southerly in summer, but at disposal sites proposed most sediment will not return to adjacent shorelines or the estuary.

(9) At the proposed offshore disposal sites the net movement of silts and clays will be northwest to the midshelf silt deposit and eventually desposited there or carried beyond the shelf by way of the Quinault Canyon. The net movement of sand will be north with some sand slowly migrating shoreward and reentering the littoral system on the beaches north of Grays Harbor.

1.11 Model Tests.

a. Description. A physical model of Grays Harbor was constructed at the WES in 1968. The model reproduced approximately 230 square miles of the prototype area, including the Chehalis River to South Montesano, the Pacific Coast for about 7.5 miles north and south of the respective jetties, and offshore areas of the Pacific Ocean well beyond the 60-foot contour. The fixed-bed model was constructed to linear scale ratios, model to prototype, of 1:500 horizontally and 1:100 vertically. From these basic ratios, the following scale relations were computed by the Froudian relations: slope 5:1, velocity 1:10, time 1:50, discharge 1:500,000, and volume 1:25,000,000. Model studies were completed in 1974 and the structure dismantled in 1980.

A list of model test reports follows:

Report 1 - VERIFICATION AND BASE TESTS
Report 1 - APPENDIX A - SUPPLEMENTARY BASE TEST DATA
Report 2 - NORTH JETTY STUDY
Report 3 - WESTPORT SMALL-BOAT BASIN
Report 4 - SOUTH JETTY STUDY
Report 5 - MAINTENANCE STUDIES OF 35-FOOT DEEP (MSL) (30-FOOT-DEEP MLLW) NAVIGATION CHANNEL
Report 6 - 45-FOOT (MSL) (40-FOOT MLLW) NAVIGATION CHANNEL IMPROVEMENT STUDIES
Misc. Paper - WESTPORT (WESTHAVEN COVE) SMALL-BOAT BASIN REVISION STUDY

b. Test Program. The model was used to determine the effects of a number of improvement studies for the project including deepening and widening the existing 30-foot channel to a depth of 40 feet. Tests generally included determining the effects on tidal heights, current velocities and patterns, salinity, flushing, and channel shoaling.

Model test results were utilized in construction of a number of project improvements implemented in the 1970's under Operation and Maintenance or Section 107 authority. These include:

- o rehabilitation of Point Chehalis groins (1972),
- o rehabilitation of North Jetty (1975),
- o realinement of South Reach channel (1976-1977), and
- o expansion of Westport Small Boat Basin (1979).

c. Widening and Deepening Studies. One of the primary purposes of the model was to investigate effects of channel widening and deepening. The depth and width parameters selected for study in the model are similar to the recommended plan that has evolved out of subsequent detailed design, cost, and benefit studies, except that channel widths being recommended are 50 to 100 feet narrower than that model tested. This discrepancy is based on the results of the physical model tests, conclusions concerning the 40-foot navigation channel follow. The existing 30-foot channel conditions are used as the base condition for comparison of the effects of a 40-foot channel modification.

(1) Upstream from the entrance area, ebb predominance near the surface will generally increase, with the most significant increase occurring above the Moon Island Reach where the width of the navigation channel decreases.

(2) Except in the Hoquiam Reach, ebb predominance near the bottom upstream from Crossover Channel will generally decrease.

(3) Large changes in ebb predominance will not occur elsewhere in the estuary; e.g., flows in South Channel will not change to any significant effect.

(4) Maximum ebb and flood velocities will decrease (generally only 0.1 to 0.3 f.p.s.) throughout the estuary.

(5) No change, or only a minimal change, will occur in surface current patterns.

(6) No change, or only a minimal change, will occur in tidal heights.

(7) A redistribution of salinity will occur with increases in the bottom waters of upper portion of the estuary. The degree of stratification will increase in the upper portion of the estuary. This effect will decrease progressively downstream especially with increasing freshwater discharge. No significant change in total salts in the estuary will occur.

(8) Salinity intrusion up the estuary will increase near the bottom. Only a minor change will occur with the low inflow, but the change will be on the order of 2-3 miles for the high freshwater discharge.

(9) Surface dye concentration levels in the model from a release at Cosmopolis (simulating a pollutant) increased, and a 3-mile shift in the location of the maximum surface peak dye concentration at MLLW slack (from the lower end of the Cow Point Reach to the lower end of the South Aberdeen Reach) occurred.

(10) Bottom dye concentration levels from a release at Cosmopolis decreased at MHHW slack throughout the estuary and below the upper end of the Cow Point Reach at MLLW slack. Above the lower end of the Cow Point Reach, increased bottom dye concentration occurred, and the location of the maximum peak dye concentration will shift upstream about 4 miles (from the lower end of Cow Point Reach to the upper end of the South Aberdeen Reach).

(11) Overall shoaling in the channel is not expected to change significantly. The model data shows increased shoaling in the Moon Island, Cow Point, Aberdeen, and South Aberdeen Reaches and slight shoaling reductions in the Hoquiam and portions of South Reaches.

1.12 Foundation Conditions.

a. Geology. Grays Harbor is a drowned coastal valley sheltered from ocean wave attack by bay mouth bars. The surrounding uplands consist of deeply weathered Tertiary sandstone, siltstone, and marine lava flows truncated by weather Pleistocene sand and gravel. Thick alluvium underlies the valley floors of the major tributary streams. The bedrock surface is highly irregular, reflecting former deeply incised drainages which developed during the Pleistocene ice age while sea level was about 200 feet lower and coastline about 10 miles west of its present position. The rise of sea level and drowning of coastal valleys was accompanied by sea cliff development until coastal "streamlining" was accomplished by the deposition of coastal littoral sand and the formation of the bay mouth bars constricting the mouth of the harbor. This permitted development of a colluvial shelf at the base of the old sea cliffs as well as the accumulation of a thick sequence of estuarine sands and silts (principally from the Chehalis Basin) in the harbor. Continued accumulation of these sediments has reduced the tidal prism to its present volume and will continue to do so.

b. Subsurface Exploration. In 1975, a geophysical accoustical profiling survey was conducted along the entire navigation channel from the Pacific Ocean to Cosmopolis, Washington. No other subsurface foundation exploration has been conducted specifically for the navigation channel widening and deepening project, but subsurface exploration has

been conducted at various sites along the navigation channel for other projects. A summary of subsurface exploration to date in the immediate channel vicinity is as follows:

Location	Exploration By
Station 5+00* (u/s of UPRR bridge) Washington State Highway 101	Washington State Department of Transportation, 1953. 12 borings to a maximum depth of 122 feet and minimum elevation -113.5 MLLW
Station 42+00 to Station 130+00 (d/s) Cow Point, Hoquiam Reach	Dames & Moore, 1964, 1971, 1974, 1977. 34 borings to a maximum depth of 113 feet and minimum elevation -127.0 MLLW
	Corps of Engineers, 1975, 1979, and 1980. 14 borings to a maximum depth of 30 feet and minimum elevation -65.0 MLLW
Station 160+00 to Station 215+00 (d/s) Hoquiam Reach	Corps of Engineers, 1975. 4 borings to a maximum depth of 21 feet and minimum elevation -63.5 MLLW.
Station 636+00 to Station 819+00 (d/s) South Reach	Corps of Engineers, 1975 and 1976. 23 borings to a maximum depth of 40 feet and minimum elevation -60.5 MLLW

(NOTE: For reference, channel alinement stationing has its origin at the UPRR bridge at Aberdeen, Washington. Stationing increases both upstream (u/s) and downstream (d/s) of the UPRR bridge.)

Additional subsurface foundation explorations will be conducted during CP&E studies.

c. Soils and Foundation Conditions. Generally, the foundation materials to be dredged will consist of medium dense to dense fine sands and silty sands with surficial soft silts and some zones of gravel, except dredging at Cow Point turning basin will encounter very dense sand, very dense gravels, and probably some glacial till and/or weathered sandstone bedrock. Special dredging methods may be required to remove these materials, or foundation exploration may provide a basis for adjusting the limits of the turning basin to avoid hard material. Sideslopes along the existing channel vary from 1 vertical (V) on 4 horizontal (H) for silts to 1 V on 3 H for sands and 1 V on 2 H for

gravels. The predominant foundation materials are sands. Based on the foundation exploration data to date and existing sideslopes, a 1 V on 3 H slope has been used for preliminary design studies for dredge cut slopes upstream of Crossover Reach. For Crossover and South Reach, initial side slope of 1 V on 5 H has been used. For the outer bar, side slopes of 1 V on 10 H were assumed. Channel dredging is not expected to affect uplands stability along any portion of the channel.

SECTION 2. DESIGN FEATURES AND ANALYSIS OF THE RECOMMENDED PLAN

2.01 General. This section presents the design features and analysis of widening and deepening the present 30-foot-deep navigation channel and replacing the Union Pacific Railroad (UPRR) bridge at Aberdeen. The present channel widths and bridge horizontal clearances are too narrow and channel depths too shallow for safe and economical navigation by existing and future forest product ships. The number of vessels with drafts exceeding 30 feet is steadily increasing. In 1975, for example, 33 percent of the vessels departing Grays Harbor had drafts of more than 30 feet and by 1980 this percentage had risen to 62 percent. Accordingly, smaller or partially loaded vessels, with greater unit transportation costs, are being used. Navigation channel improvements and bridge modifications would provide safe navigation and allow efficient movement of waterborne commerce by allowing use of larger vessels with increased cargo capacity.

2.02 In determining the needed channel improvements, the major design considerations were those related to channel dimensions (width and depth) and alinement which would afford safe and efficient vessel operation. The selection of channel depth was dependent upon the loaded draft of expected vessels, squat, trim, maneuverability, water density, wave action, tides, and type of bottom. Factors considered in determining channel widths were: existence of a passing situation, vessel controllability, vessel speed relative to channel bottom, current velocity and direction, wave action and direction, and the characteristics of the channel banks.

2.03 Project Description. The federally authorized depth of the Grays Harbor navigation channel from the Outer Bar to Cosmopolis is presently 30 feet below MLLW. The general layout is shown in plate 1. The major features of the recommended plan provide for deepening/widening and Federal maintenance of the navigation channel in Grays Harbor from the Outer Bar to Cosmopolis (see plates 1 and 3-6) and replacement of the UPRR bridge over the Chehalis River at Aberdeen (see plate 8). Typical channel sections and dimensions are shon on figure D2-1.

2.04 Details of the deep-draft navigation channel improvement are as follows:

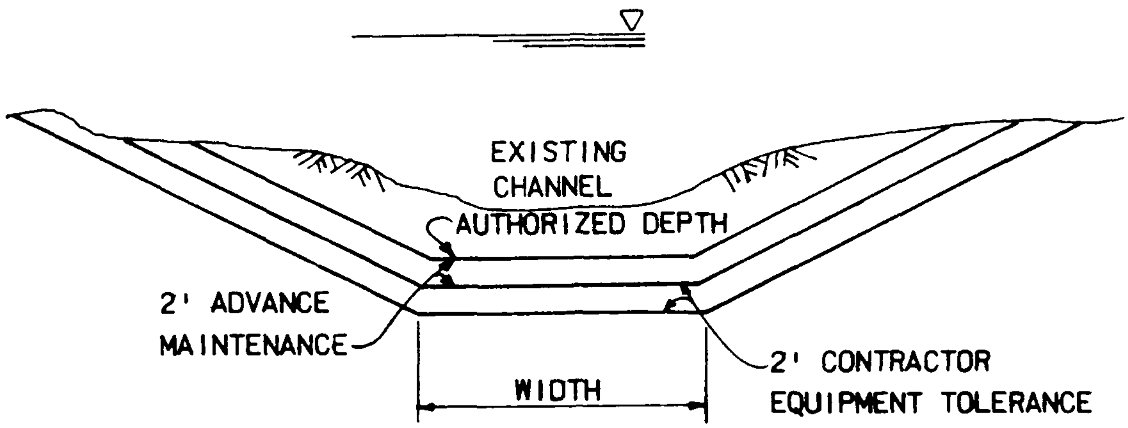
a. Outer Bar reach widened and deepened to 1,000 feet by 46 feet.

b. Entrance reach widened and deepened to 1,000 feet to 600 feet wide by 46 to 38 feet deep.

c. South reach widened and deepened to 400 feet by 38 feet.

d. Crossover reach widened and deepened to 400 feet by 38 feet.

CORPS OF ENGINEERS — U. S. ARMY



CHANNEL CHARACTERISTICS			
REACH	AUTHORIZED DEPTH (feet below MLLW)	WIDTH (feet)	SIDE SLOPE
OUTER BAR	46	1000	10H 1V
ENTRANCE	46-38	1000-600	5H 1V
SOUTH	38	400	5H 1V
CROSSOVER	38	400	5H 1V
MOON ISLAND	38	350	3H 1V
HOQUIAM	38	350	3H 1V
COW POINT	38	350	3H 1V
ABERDEEN	36	250	3H 1V
SOUTH ABERDEEN	36	250	3H 1V

☆U.S. GOVERNMENT PRINTING OFFICE: 1976-788-301

FIGURE D2-1

e. Moon Island reach deepened to 38 feet.

f. Hoquiam reach deepened to 38 feet.

g. Cow Point reach deepened to 38 feet.

h. Aberdeen reach widened and deepened to 250 feet by 36 feet.

i. South Aberdeen reach widened and deepened to 250 feet by 36 feet.

j. Replacement of the UPRR bridge with a vertical lift structure having a horizontal clearance of 250 feet and a vertical clearance of 140 feet above MHHW.

k. Construction of three new turning basins.

l. Local dredging and maintenance of berthing areas.

m. Local relocation of utilities disturbed by the project.

n. Mitigation of environmental losses caused by the project.

o. Revision of a fendering system at the U.S. Highway 101 bridge.

p. Addition of aids to navigation.

2.05 During initial project improvements, an estimated 15.25 million c.y. of sand and silt would be dredged from Cow Point reach downstream through the Outer Bar and an estimated 1.85 million c.y. of silt and sand would be dredged upstream of Cow Point reach. Material will be disposed of in deep water off Point Chehalis and along South Jetty and at ocean sites about 3-1/2 miles off the coast as shown on plate 7. Clamshell dredging will be used in the upper reaches (South Aberdeen-Moon Island) and hopper dredging will be used in the lower reaches (Outer Moon Island-Outer Bar). Proposed equipment, dredging quantities and schedule of work for the various reaches are shown in table 3-2, main report, and plate 10.

2.06 Annual dredging and disposal of an estimated 2.35 million c.y. of material will be necessary to maintain authorized project depths. About 2.2 million c.y./year will need to be removed from the Cow Point reach downstream through the Outer Bar and 150,000 c.y./year upstream of Cow Point reach (see table 3-2, feasibility report).

2.07 Channel Design Criteria. The recommended channel improvement was generally designed in accordance with the Corps of Engineers' ER 1110-2-1404 dated 24 September 1981, "Deep Draft Navigation Project Designs," and references thereto. In addition, data from the "Columbia River Entrance Channel Deep-Draft Vessel Motion Study" (Tetra Tech,

1977-80) was utilized in entrance and bar design and extensive discussions were held with Grays Harbor pilots and the USCG to determine what navigational problems are being encountered and what improvement would be desirable. Discussions were also held with the Port of Grays Harbor, city of Aberdeen, UPRR Company, and Washington State Department of Highways regarding the design and construction of a new railroad lift span bridge and a fendering system for the highway bridge (see appendix B for pertinent correspondence).

2.08 Channel Design.

a. Vessel Traffic and Movements. Deep-draft vessels calling at Grays Harbor are limited to foreign export timber and wood chip carriers. Port calls are on the order of 200 to 300 vessels per year. Inbound vessels are either empty or partially loaded and outbound transits either partially or fully loaded. This practice is expected to continue in the future with or without the channel improvement project, except that increased numbers of fully loaded outbound transits will occur with the project. Almost 100 percent of outbound transits from dock areas begin at low tide or within 3 hours after low tide because: (1) transits can be made against incoming flood tide currents for better steerage; (2) provides a safety factor, in case of power failure, etc., against being set on Point Chehalis or South Jetty rocks; (3) provides additional keel clearance (with a rising tide) in the outer harbor and bar; and (4) allows time for vessel transit (2 to 3 hours) and return of the pilot boat across the bar and into the harbor before hazardous ebb flow conditions begin. 1980 records show outbound vessel drafts range from about 25 to 34 feet (includes trim), with average size vessels in 22,000 deadweight ton (DWT) category. Inbound transits can be made at most tide phases; however, normal practice is to time arrival at the docks near high tide to facilitate turning of the vessel. Nearly all vessel turns are made on the inbound transit when vessels are light loaded and at high tide. All inbound transits through the bridges are scheduled for slack water conditions at the bridges, usually high slack, to provide turning depth and weaker currents.

b. Design Vessels. Deep-draft vessels presently calling at Grays Harbor range in size from about 15,000 to the 44,000 DWT Hoegh class vessels. For design vessel purposes, the channel can be divided into two segments: (1) upstream of Cow Point through the railroad and highway bridges and (2) from Cow Point and downstream. Future fleet projections for the period 2010-2040 are used for design vessel analysis; however, the fleet mix projected for this period is not significantly greater than for the 1990-2010 period of the project life (see appendix C). The design vessels selected for the two channel segments are those that carry the majority of product tonnage. The channel dimensions selected for the above design vessels were then checked for adequacy of movement of the largest vessels expected to call at Grays Harbor.

(1) Upstream of Cow Point. Timber and wood chip carriers call above the bridges (Aberdeen and South Aberdeen channel reaches) and account for about 35 to 40 percent of the total Grays Harbor tonnage. From discussion with pilots, the highway bridge and a new railroad bridge would still restrict the vessel size to about 600-foot length and 90-foot beam. For these size vessels, wood chip carriers have loaded drafts of 29 to 31 feet and timber carriers have loaded drafts of 33 to 35 feet. Timber carrier calls are three to four times that of the wood chip carriers and a vessel draft of 34 feet was selected for design purposes.

(2) Cow Point and Downstream. Vessels calling at Cow Point and downstream terminals are timber carriers only. Majority of these vessels will be in the 625-foot length, 90-foot beam size with loaded drafts of 34 to 35 feet. The largest vessel expected is the Hoegh class with lengths of 658 feet, beams of 101 feet, and loaded drafts of 37 feet. Design vessel selected is a vessel with 625-foot length, 90-foot beam, and 35-foot draft. This size vessel or larger is expected to carry over 50 percent of the tonnage of this channel segment.

c. One-Way Traffic. With the relatively small number of vessels arriving and leaving Grays Harbor, design for two-way traffic is not warranted. Certain portions of the estuary such as north of Point Chehalis and at Moon Island reach have adequate room for passing of vessels. Under most passing conditions, light loaded inbound vessels can find adequate water depths either at the channel bend widenings or in naturally deep areas along the channel. Pilots are equipped with ship-to-ship radio and passing situations can be discussed between pilots.

d. Channel Alinement. Channel alinement is shown on plates 3 through 6. The deeper channel alinement is generally along the existing channel with minor modifications to take advantage of naturally deep parts of the estuary. The channel follows the thalweg of the Chehalis River and generally is alined with existing current patterns in the estuary, minimizing annual maintenance dredging and maximizing safe navigation for ships. Ship sizes and speeds were considered in the degree of turns in the alinement, but alinements are generally governed by the existence of deep water. The entrance channel is alined through deep water off Point Chehalis and along the South Jetty. The outer bar channel is alined along a southwest azimuth because of pilot preference and to minimize initial and maintenance dredge quantities. Outgoing ships will quarter or be abeam to most swell along this alinement. Discussions with pilots at Grays Harbor indicate that they are more concerned about being set by the currents and wind and by vessel pitch than roll of the vessel and present bar transits are usually made in a southwest direction. Incoming vessels are empty or light loaded and can usually navigate safely with quartering or stern seas and, because of natural depths over other parts of the outer bar, would not necessarily have to follow the designated outer bar channel into the harbor.

e. Channel Depth. Factors involved in the design of channel depths included: design ship draft, minimum safe clearance, freshwater sinkage, trim, squat, tidal effects, and wave action. These factors are discussed below:

(1) Design Ship Draft. The design ship drafts have previously been discussed and are 34 feet above the bridges and 35 feet from Cow Point downstream. Vessels up to 37 feet of draft are the maximum expected on outbound transits and can navigate the channel safely with favorable environmental conditions and tide delays.

(2) Minimum Safe Clearance. A minimum of 2 to 3 additional feet in depth is required under the keel after all the other requirements for depth have been met. This clearance is needed to avoid damage to ship propellers from sunken timbers and debris, to avoid fouling of pumps and condensers by bottom material, to reduce disturbance and displacement of bottom materials, to allow for unexpected shoals, to provide adequate ship maneuverability, and provide a safety factor against grounding.

(3) Freshwater Sinkage. Passing from seawater with a density of 1.026 into freshwater with a density of 0.9991, a vessel's displacement will increase approximately 2 to 3 percent depending upon the hull design. During periods of high freshwater inflows from the Chehalis River there is a high percentage of freshwater in the inner harbor channels. Accordingly, freshwater sinkage is a factor in determining depths below the keel from Hoquiam Reach to Cosmopolis. One foot was added to the clearance requirements beneath the keel for these reaches of the channel influenced by freshwater riverflow.

(4) Trim. The difference between vessel draft at midship and the bow or stern is termed trim. It is often difficult and expensive to load a ship at even keel and a nose down vessel does not maneuver well, so a vessel is often loaded to keep the stern lower than the bow. Observations of present vessel loading practices at Grays Harbor show the loaded stern drafts are commonly up to 1 foot greater than at midship. Hence, an additional 1 foot was added to the required design vessel channel depth. For the Entrance and Outer Bar reaches the vessel was assumed to be evenly trimmed as this condition would be most critical for bow excursion as a result of wave action.

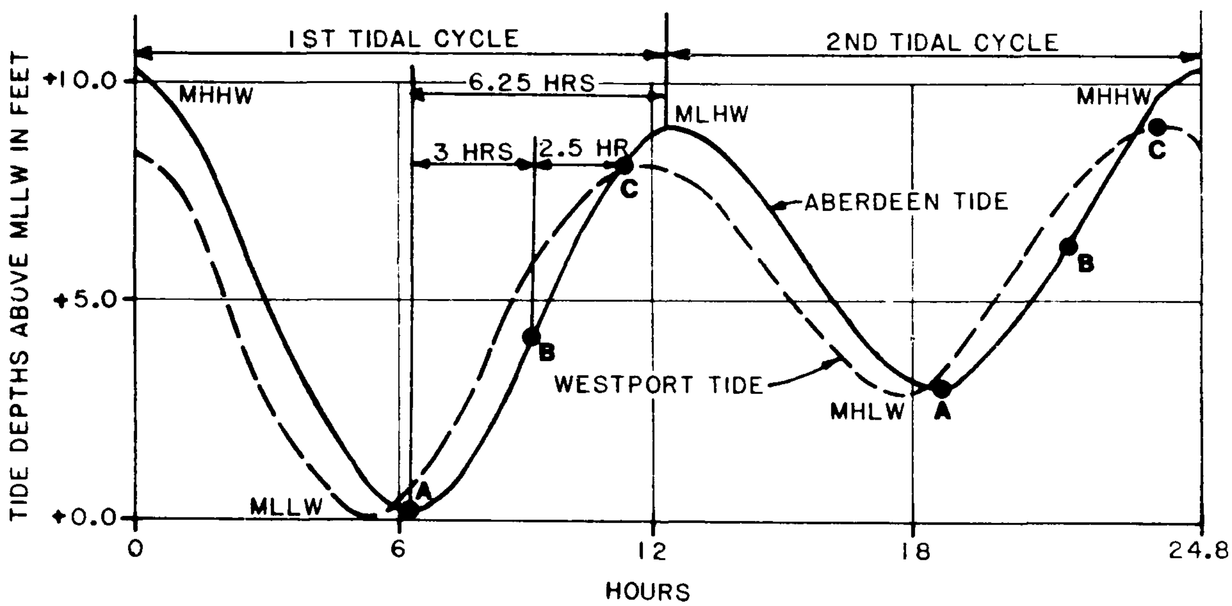
(5) Squat. A moving ship causes a drawdown of the water surface causing the vessel to ride lower relative to the water surface fixed datum or squat. The effects of squat on vessel bottom clearance is important only to outbound loaded ships as inbound ships are light loaded. Many vessels will leave the docks under flood tide conditions with currents up to 2 knots which increases the ship's relative speed through the water. Squat calculations are based on varying ship speeds and vessel sizes for different reaches of the navigation channel. Upper harbor speeds were assumed at 6 knots and outer harbor and bar speeds at

10 knots (velocities are speeds through the water and include 2 knots of tidal current). Vessel speeds would normally be somewhat greater under high tide and fair weather conditions but would not govern for channel depth design requirments. For the critical case of keel clearance design, wave conditions would be severe and tide elevations would be below or near midtide height and pilots would reduce ship speed under these conditions, thus reducing the need to allow for a squat factor. In summary, squat would be negligible in the Entrance and on the Outer Bar channels (where depths outside channel limits are only slightly less than that of the channel), but would be 1/2 to 1 foot in the inner and upper harbor reaches.

(6) Tidal Effects. The reference datum, 0.0 foot, for the project area is MLLW. Tides in the area are of the mixed type with two high and low waters in each tidal day. A tidal analysis shows that on the average, over a period of 1 year, the tide is below the reference datum 6 percent of the time. A tidal delay occurs when a vessel must remain berthed and wait for a certain minimum tidal elevation before safely transiting the waterway. For Grays Harbor, a tide delay of up to 2 to 3 hours is considered acceptable for the diurnal MLLW tide before significant vessel delay costs are incurred. During a 1-hour period, the rise in tide from MLLW is about 2 feet. Vessel movement practices and relationship of Aberdeen and Westport (ocean) tides is shown on figure D2-2.

(7) Waves. A major consideration in the design of channel depth is the increase due to complex motions (pitch, heave, roll) of vessel wave action. This is most critical in the Outer Bar and Entrance channels where waves are more severe than in the outer and inner portions of the estuary. The graphical methods described by L. E. Van Houten, presented in the 1965 Report of Proceedings, International Navigation Congress, but primarily shipboard studies off the Columbia River, were used to determine the added depth below the keel due to wave action. Wave action becomes progressively greater as loaded vessels transit the navigation channel from upstream to the outer bar. In the Cosmopolis to Hoquiam area, vessels are exposed to local, short period wind waves of 1 to 3 feet that have little or no effect on vessel motion. The outer harbor channels, Moon Island to South reaches, are exposed to ocean sea and swell that enter the jettied entrance. Ocean sea and swell with heights on the order of 3 feet occur (with the vessel still being able to transit the Entrance and Outer Bar channels) in these reaches, either head-on or on the quarter of the ship's bow. Ship's motion from wave action in these reaches increase 1 to 3 feet. As the vessel transits the entrance, wave action becomes more severe, being either head-on or on the quarter of the bow, depending on the wave direction and bearing of the ship's course. Near Point Chehalis, waves will have an easterly direction, putting the waves on the ship's starboard bow because of the ship's southwest course. Wave heights in the entrance area vary significantly from a few feet at the east end to conditions similar to the bar at the jetty end. At the seaward end of South Jetty, the vessel turns southwest, generally putting the ocean waves on its starboard beam or quarter.

TIDES AND VESSEL MOVEMENTS



A TO B: DEPARTURE TRANSIT WINDOW AT DOCKS

B TO C: BAR CROSSING WINDOW

FIGURE D2-2

During May 1978 through April 1980, Tetra Tech shipboard monitoring of 53 vessel transits was undertaken on the Columbia River bar and entrance; including vessel vertical and horizontal motions. Environmental conditions are similar at the Grays Harbor entrance and bar to that at the Columbia River mouth; however, vessel transit differences exists. These differences include:

o only outbound loaded transits are made from Grays Harbor,

o outbound transits at Grays Harbor are normally made during flood tide - thus additional tide depth and more moderate flood tide wave conditions can be assumed at Grays Harbor,

o Grays Harbor vessels are limited to timber and wood chip carriers - with less draft than the design vessels on the Columbia River, and

o pilot boats at Grays Harbor are smaller and must return to the harbor during flood tide when wave ation is less severe.

For Grays Harbor, the maximum significant wave height allowable for outbound transits is about 8 feet (exceeded about 9 percent of the time) for flood tide conditions. Tetra Tech data shows maximum excursion of the ship's bow will be less than 14 feet 95 percent of the time under these conditions. Thus, this allowance for channel depth on the outer end of the Entrance channel and the Outer Bar must be designed for.

(8) Summary. Recommended channel depths are summarized in table D2-1. Wave action allowances for depth under the keel for various reaches of the channel are shown in table D2-1. In addition to these depths, an allowance of 2 feet for dredging overdepth and 2 feet for advanced maintenance will be included in initial and future maintenance dredging work.

TABLE D2-1
SUMMARY OF CHANNEL DEPTHS FOR DESIGN VESSEL (FEET)

	Above Bridges	Inner Harbor	Outer Harbor	Entrance 1/ Channel	Outer 1/ Bar
Design Ship Draft	34.0	35.0	35.0	35.0	35.0
Minimum Safe Clearance	2.0	2.0	3.0	3.0	3.0
Freshwater Sinkage	1.0	1.0	0	0	0
Trim	1.0	1.0	1.0	0	0
Squat	1.0	1.0	0.5	0	0
Wave Action	0	0	2.0	5-14	14.0
Tide	-2.5	-2.5	-3.5	-5 to -6	-5.0
Totals-Channel Depths	36.5	37.5	38.0	38-46	46.0
Recommended Depths	36.0	38.0	38.0	38-46	46.0

1/For critical design condition, vessels are assumed to be evenly trimmed (bow excursion is critical), and pilots will reduce vessel speed and/or time transits for near high tide during severe wave conditions.

f. Channel Width. Factors involved in the design of channel widths are: vessel characteristics; waves, currents, visibility, and winds; one or two-way traffic; and channel depths and bank characteristics, as previously discussed. The total width in channel design for Grays Harbor is composed of the maneuvering, travel lane, and bank clearance lanes. The maneuvering lane width is increased for yaw and set of the vessel in reaches of the channel where currents, winds, and wave action affect the ships' course. "Evaluation of Present State of Knowledge of Factors Affecting Tidal Hydraulics and Related Phenomena" recommends maneuvering lane widths of 160-200 percent of the ships' beam and bank clearances of between 60-150 percent of ships' beam, and recommends consideration of increasing the channel width for yaw, for strong wind and current set, wave action, and difficulty to the pilots in determining channel limits. Guidance available in correlating all of these factors and the channel width determinations are based on data furnished in the above report and discussion with Grays Harbor pilots. Width of the Outer Bar and outer portion of the Entrance reach was designed primarily from data by Tetra Tech Corporation in their monitoring of deep-draft vessel tracks in the entrance channel of the Columbia River, known conditions in Grays Harbor, and discussion with pilots working Grays Harbor. Channel design widths are shown on figure D2-1 and in table D2-2.

Vessels entering or leaving the Grays Harbor entrance generally proceed in a yawed condition from Crossover reach through the bar to stay within channel boundaries. In open waters, the navigator of a deep-draft vessel has considerable latitude to perform adjustments to offset wave, wind, and current forces acting on a ship. In the shallow waters of the entrance, rudder response is much slower and additional power is required over that for equal speed in open waters. Current direction is to be considered in that a strong current moving at an angle to the channel requires the pilot to proceed in yawed position. Wave action often will affect the course of the vessel, particularly when the seas are quartering. The sailing course may become erratic as the navigator is constantly required to compensate for wave forces. Similarly, wind, fog, heavy rain, or snow are factors in the design of the entrance width. During severe meteorological conditions, vessels may have to anchor in the outer harbor before attempting outbound transits and for inbound transits or lay to at sea for safety reasons. Often the governing factor at Grays Harbor is the ability of the pilot boat to transit the bar. In addition to the external factors, vessel characteristics such as length, beam, draft, speed, rudder area, single or twin propellors, and hull shape affect navigabilty of the entrance.

For a relatively open entrance channel such as Grays Harbor, flow under the vessel is restricted far more than on the sides. The shallow water effect causes an increase of pressures and velocities under the keel and thereby increases the water resistance and reduces the general performance of the ship and effectivenes of the rudder. In general, there are no precise methods for computing all of the above elements, but various investigations have been made that can furnish guidance. Unlike the

analysis of vertical ship motions, the Tetra Tech study found there was no reliable formula found for relating environmental conditions and ship characteristics to the horizontal motions meaured in the monitoring program. The channel width design is therefore based on the distribution of effective lane width reported in Tetra Tech (1980). Due to equipment problems with the vessel heading sensor, horizontal motion data was obtained on 40 of the 53 transits monitored. The effective lane width, a combination of vessel yaw and track width, reported ranged between 239 feet and 1,343 feet. The average effective lane width was 410 feet and standard deviation was 195 feet. The maximum lane width required during the first year's monitoring effort was 781 feet on voyage 15, while during the second year a maximum lane width of 1,343 feet was required on voyage 44. Voyage 15 was inbound on the tanker HILLYER BROWN on 15 December 1978 with 15-foot-high waves from the west and winds south-southeast at 11 knots. Voyage 44 was outbound on the auto carrier WORLD WING on 6 February 1980 with 14-foot-high waves from the west and winds west-southwest at about 30 knots. Comparison of the ship track plots and the ships heading, versus time plots, indicates that the lane width required in voyage 15 is predominantly due to waves, while that required in voyage 44 is predominantly due to wind conditions. For instance, the track plot for voyage 44 is a much smoother curve than for voyage 15. The importance of this is that while the lane width required for voyage 44 is twice that required for voyage 15, it appears that maneuvering was much less controllable in voyage 15. U.S. Army Corps of Engineers, Portland District, preliminary evaluation of the Columbia River data show that 95 percent of the transits will have an effective channel width of 730 feet or less.

Discussion with pilots at Grays Harbor indicates a preferrence for an Outer Bar channel width of up to 1,200 feet but that 1,000 feet is a minimal acceptable width. Some of the pilots exercise to-and-fro course changes during the bar transits to obtain the safest combination of pitch and roll but which also increases channel width requirements. With ranges (some 2 to 3 miles astern for outbound transits) and buoys often obscured by wave and weather conditions, and the high potential for serious damage in case of a grounding, a channel width of 1.000 feet is recommended for the outer Entrance and Bar channels.

TABLE D2-2
RECOMMENDED CHANNEL WIDTHS

(1) Outer Bar and Entrance Channel (West Portion). Use 1,000 feet as discussed above.

(2) Entrance Channel (East Portion):

Travel Lane Width = 200 percent of beam (90 feet)	=	180 feet
Yaw - Sine 10^{o} x Length (625 feet)	=	109 feet
Bank Clearance Lanes = 300 percent of beam (90 feet)	=	270 feet
TOTAL	=	559 feet
USE	=	600 feet

TABLE D2-2 (con.)

(3) South and Crossover Reaches:

Travel Lane Width = 200 percent of beam (90 feet)	=	180 feet
Yaw - Sine 7-1/2° x Length (625 feet)	=	82 feet
Bank Clearance = 180 percent of beam (90 feet)	=	162 feet
TOTAL	=	424 feet
USE	=	400 feet

(4) Moon Island Reach:

Travel Lane Width = 180 percent of beam (90 feet)	=	162 feet
Yaw - Sine 5° x Length (625 feet)	=	55 feet
Bank Clearance = 150 percent of beam (90 feet)	=	114 feet
TOTAL	=	352 feet
USE	=	350 feet

(5) Hoquiam and Cow Point Reaches:

(Tug assist available during adverse conditions)		
Travel Lane Width = 180 percent of beam (90 feet)	=	162 feet
Yaw (minimal, but exists for these reaches)	=	25 feet
Bank Clearance = 1 at 60 percent of beam (90 feet)		
1 at 100 percent of beam (90 feet)	=	144 feet
TOTAL	=	331 feet
USE	=	350 feet

(6) Aberdeen and South Aberdeen Reaches:

(Both reaches with full tug assist)		
Travel Lane Width = 160 percent of beam (90 feet)	=	144 feet
Yaw (assumed negligible with tug assist)	=	0 feet
Bank Clearance = 120 percent of beam (90 feet)	=	108 feet
TOTAL	=	252 feet
USE	=	250 feet

g. Turning Basins. Purpose of the turning basins is to allow vessels to reverse direction in a navigation channel. The total width of the turning basin is recommended to be 150 percent of the length of the design vessel. The normal shape is that of a trapezoid with the long side tangent to the edge of the channel. The short side will normally be 150 percent of the length of the design vessel. Two turning basins are presently authorized; however, neither of these are maintained or used. Three turning basins, shown on plates 1, 3, and 4, are

proposed for the project and are discussed below. These turning basins were discussed extensively with pilots as to needs and locations.

(1) Cow Point Turning Basin. The turning basin at Cow Point would be constructed between Terminals No. 2 and 4 in the vicinity of an existing authorized channel width of 800 feet and depth of 30 feet. The proposed turning basin is 1,000 feet wide (includes 350 feet of channel width) and is 1,000 feet wide on the outside tangent with a depth of 38 feet. This turning basin is designed for the largest vessel expected at Grays Harbor, the 658-foot-long, 37-foot draft Hoegh class vessel. In addition to turning, the turning basin area will allow vessels rounding the bend at Cow Point to swing several hundred feet out from Terminal No. 4 to avoid suction on moored vessels. This problem is so serious that tugs assisting the upbound vessels are at times released to push against the moored vessels while other vessel passes this area. Proposed depth of 38 feet will be the same as channel and is required both for vessel transit and turning. At times vessels will have to turn at the beginning of their outbound movement; i.e., loaded and near low tide. Allowance for squat would not be needed, although allowance for freshwater sinkage, trim, and a minimal bottom clearance is required. For the maximum draft vessel of 37 feet, pilots could wait for a few feet of tide after low slack to provide the necessary bottom clearance allowances and still make the channel transit across the bar and return the pilot boat into the harbor before beginning of ebb on the bar.

(2) South Aberdeen Turning Basin. Inbound transits are usually made so that arrival at the bridges and for turning upstream of the bridges is coincident with high slackwater. Turns are presently made at Elliott Slough, see plate 4, at high tide and on the inbound, light loaded condition. In this confined reach of the channel, the ship is impossible or, at best, difficult to turn during low tide, ebb tide, or high Chehalis River discharge. At present, pilots will not transit the bridges stern first, so turns must be made above the bridges and in all but the rarest of cases, the turn must be made at near high slackwater on the inbound transit (in a light loaded condition). These turns, even in the most ideal conditions, are considered hazardous. A depth of 30 feet is recommended for the turning basin with width and outside dimensions of 750 feet. The 30-foot depth and 750-foot width will still require fully loaded vessels to turn at high tide but will allow light loaded inbound vessels to turn at low tide. The 750-foot width does not meet general design criteria requirements for a width of 1.5 by the 600-foot design vessel (900 feet); however, a width of 900 feet would require dredging of either substantial commercial or wetland areas. Pilots have stated the design is adequate as proposed and will not impose undue delays to vessel transits. The existing 550-foot-wide turning basin at Cosmopolis, authorized in 1954, has not been maintained in recent years because of high channel shoaling and inadequate widths for safe turning.

(3) Hoquiam Turning Basin. Pilots presently turn in the naturally deep water opposite, or just upstream, from the 1980 constructed ITT Rayonier dock at harbor mile 4.5. This location is about 2-1/2 miles downstream of the proposed Cow Point turning basin and is proposed as a turning basin for vessels calling at the downstream part of the Aberdeen/Hoquiam industrial area. Anderson-Middleton Company has an approved permit to construct a dock at the upstream end of where pilots now turn. The turning basin will be 750 feet wide (including 350 feet of channel width) by 750 feet long with a depth of 30 feet. The turning basin area has natural depths of 25 feet MLLW and pilots make turns based on ship drafts, tide, and by adjusting times of arrival and departure. As with the proposed south Aberdeen turning basin, the width of 750 feet does not meet design criteria, but pilots state the proposed dimensions are adequate and depths reasonable. Vessels can turn at the upstream Cow Point turning basin, which may be required at times because of the additional depth proposed at the Cow Point turning basin. Initial dredging of the turning basin is 150,000 c.y. and maintenance dredging is projected to be relatively low.

h. Channel Side Slopes. The channel side slopes would be 1 foot V on 3 to 10 feet H. Side slope design along the channel vary from 1V on 2-5 H. Based on foundation exploration data and existing side slopes, side slopes of 1 V on 3 H design were selected for the inner harbor, 1V on 5H for the outer harbor reaches. Outer Bar side slopes would be flattened to 1V on 10H to prevent rapid shoaling along the channel edge from high littoral drift volumes and high wave energy exposure.

2.09 Relocations.

a. Utility Relocations. Utilities, including waterlines, sewerage mains, and power cables crossing the navigation channel, are listed in section 3 of this appendix.

b. Railroad Bridge Replacement and Modifications. Many timber and wood chips vessels now transporting forest products in world-wide trade exceed 30,000 DWT. Most of these vessels cannot call above Cow Point because the existing 30-foot-deep channel is too shallow and vessel movement upstream of the UPRR bridge is hampered by the restriction of the 125-foot-horizontal clearance of the railroad bridge. Maximum size vessels transiting the bridges are about 550-foot length, 80-foot beam, and 32-foot sail drafts. Both pilots and shipping agents are reluctant to schedule larger vessels to call in this section of Grays Harbor because of the liability posed by the bridges. Passage is further complicated by the fact that the navigation span of the railroad bridge is not alined with the navigation span of the state highway bridge located about 200 feet upstream. Crosscurrents and the channel alinement above the bridges also contribute to the navigation difficulties through the bridges. The navigation span of the highway bridge is adequately alined with prevailing currents and the depth of piers will permit channel deepening to 40 feet MLLW. Replacement of the UPRR

swing-span bridge at Aberdeen with a 140-foot MHHW clearance lift span is proposed to increase the horizontal channel clearance from 125 feet to 250 feet.

The design loading for the replacement bridge is Cooper E-80. The maximum lifting velocity on the span is about 2.5 feet per second, with 2 minutes required to raise the bridge and a 40 second acceleration/deceleration interval. The lift span will be supported between two towers. Cables passing over sheaves at the tops of towers suspend the span and its balancing counterweights. The lift span is a through-type Warren Truss with verticals and the towers are tapered ridged frames. All structural steel in the lift and approach spans is A-441 with a yield strength of 50 kips per square inch. Treated timber fenders will be placed to protect the bridge piers. The total horizontal width between fenders will be about 250 feet. A plan and elevation of the proposed bridge are shown on plate 8. Railroad traffic would use the bridge during construction and sequencing of rail and river traffic would be as shon on plate 9.

c. U.S. Highway 101 Bridge Fenders. The highway bridge fendering system presently provides 150 feet of horizontal clearance. The north pier fender extends into the channel to meet the UPRR swing span when in its open position. Replacement of the railroad bridge will require replacement of at least the north fender which will provide a horizontal channel clearance of 185 feet. The USCG will determine final fendering requirements for the bridge. Cost of the fendering system will be borne by the Washington State Department of Transportation.

[illegible].10 Dredging and Disposal

a. General. The recommended plan is to use hopper and clamshell dredges with material disposed of in deep water at two sites off Point Chehalis and the South Jetty, and at two open ocean sites each approximately 3-1/2 miles to sea. If materials are found to be unsuitable for water disposal, limited capacity upland sites are available in the inner harbor. Plates 3 and 7 show the proposed dredged material disposal sites. Future studies will again evaluate the disposal plan; alternatives include use of gravels from the Cow Point turning basin as structural fill, fill for a Bowerman Basin industrial site, etc. Scour action at the existing (1982) deep-water disposal site at Point Chehalis has allowed disposal of 1.5 to 2.5 million c.y. of existing maintenance material per year without any apparent long-term accumulation of material. Although there has been no previous disposal at the South Jetty site, model test, drifter studies, and current studies indicate that this site has an even greater potential for seaward scouring and also includes the added benefit of reducing the potential for undermining of the South Jetty. The Point Chehalis and South Jetty sites have the advantages of being the closest to the source of the material and because of their semiprotected location they can be utilized at all times of the year. Accordingly, the selected plan proposes to utilize these sites to the maximum extent possible. After the start of initial dredging, there would be about 3 years of scour before there would be any major maintenance disposal. This will be ample time for the scour of the initial sands and silts disposed at these sites. About

9.9 million c.y. of the 17.1 million c.y. of initial dredging will be placed in the outer harbor South Jetty and Point Chehalis sites. The remainder of the material, 7.2 million c.y., will be dumped offshore approximately 3-1/2 miles to sea. A summary of the dredge equipment, disposal sites, quantities, and costs for dredging and dredge material disposal of the initial dredging and the annual maintenance dredging quantity and costs are presented in table 3-2, main report. Disposal of the harbor maintenance dredge material would be at the Point Chehalis and South Jetty sites. Disposal of Outer Bar maintenance material would be at the southwest 3-1/2-mile disposal site.

b. Maintenance Dredging. Maintenance dredging requirements for th widened and deepened channel are not expected to be significantly different from on-going maintenance requirements, except dredging on the Bar channel will be required. Estimates for future maintenane are based on WES model studies for the harbor channels and bar dredging requirements at other Pacific Northwest ocean ports.

In the WES model test the existing channel, or base condition, was first adjusted to duplicate historical shoaling patterns, and then the enlarged channel was constructed and the shoaling tests duplicated. The tests were conducted for five segments of the channel using gilsonite, a solid hydrocarbon with a specific gravity of 1.035 as "shoal material." A summary of effects of the 40-foot channel on various channel shoaling segments is presented in the following tabulation. The existing maintenance dredging requirements and that projected for the widened and deepened plan are also shown for comparison purposes.

Channel Segment	40-Foot Shoaling Indices	Existing Maintenance (1,000 c.y.)	Projected Maintenance (1,000 c.y.)
Cow Point, Aberdeen, and South Aberdeen	110.7	250	350
Hoquiam	91.5	50	100
Moon Island	116.2	150	200
Crossover	100.6	400	450
South	92.9	400	450

1/The shoaling index for a plan is determined by dividing the shoaling of a plan by the total shoaling of the base test and multiplying by 100.

The shoaling indices show both increases and decreases in future shoaling. For the feasibility report, a worst case shoaling rate was assumed to assure that environmental impacts and future project costs would not be understated. Although the model data indicates little or no overall

increase in shoaling, over existing conditions, the increase being used for reporting purposes is about 25 percent. The Outer Bar maintenance requirements are estimated at 800,000 c.y. per year.

2.11 Disposal Sites. The disposal sites selected for the recommended plan are discussed below. Additional information on the hydraulics and sedimentation processes at these sites are included in "Technical Support Report, Tidal Hydraulics and Oceanography," March 1982.

a. South Jetty Disposal Area. The presently authorized entrance channel, 350 feet wide and 30 feet deep MLLW, lies immediately adjacent to the South Jetty. Maintenance dredging is not required to maintain the authorized width and depth. Natural currents have scoured areas immediately adjacent to the jetty to depths of over 70 feet below MLLW. The proposed entrance channel, 46-38 feet deep, with varying width, would require a minor amount of initial and annual maintenance dredging of shoaled areas to maintain the proposed width and depth. Deposition of dredged material in these scoured areas would assist in preventing undermining of the toe of the South Jetty. The capacity of the area below the 50-foot MLLW depth is sufficent to receive the 5 million c.y planned for disposal at the site. Ebb tide currents would scour the disposal material, moving the material to deep water outside the harbor and increasing the capacity for initial disposal quantities and future maintenance dredge material. A minimal amount of this material may settle in the outer bar channel and may be recirculated back to the estuary. Initial Outer Bar dredging quantities include 1 million c.y. of material that is estimated to be transported from the Point Chehalis and South Jetty disposal sites to the bar channel. The natural scouring would permit deposition of over 2 million c.y. of sands annually from maintenance dredging.

b. Point Chehalis Disposal Areas. These sites are in a deep area off the tip of Point Chehalis with natural depths of over 80 feet below MLLW. The sites are 1/4 and 0.6 miles west-southwest of the existing disposal site currently receiving about 1.5 to 2.0 million c.y. annually of dredged material. Most of the deposited material is expected to migrate to sea, similar to the South Jetty site, by ebb tide currents, while a small portion of it may be recirculated within the estuary. In general, coarser dredge material will be disposed of at these sites with the finer materials at the South Jetty and ocean sites. This site would be suitable for receiving both initial and annual maintenance dredged material. Ebb tide currents will continue to scour the area, moving the material alongside the jetty to deep water outside the harbor and increasing the capacity for initial and future maintenance disposal quantities. The material moving along the South Jetty will also assist in preventing undermining of the toe of the South Jetty. In combination with South Jetty disposal, an estimated 1 million c.y. of this material is expected to settle in a short length of the Entrance channel or in the Outer Bar channel, requiring removal by dredging. Based on past maintenance dredge disposal experience, the natural scouring would permit deposition of over 2 million c.y. of sand material annually from maintenance dredging.

c. Ocean Disposal. Ocean disposal would be from hopper dredges or by clamshell loaded bottom dump barges. Disposal would be about 3.5 miles seaward off the ends of the entrance jetties in about 100 feet of water. Detailed studies of ocean sites have not been made other than obtaining surface sediment samples and some limited drogue current studies. General conclusions on ocean sites at Grays Harbor are from related studies at other locations. Fine material disposed of at these sites are expected to be transported offshore while a part of the sands material will have an onshore movement but at a very low transport rate. Related studies are described below:

(1) Field studies (1972 Proceedings Coastal Engineer) on the San Francisco bar (30 to 45 feet) were conducted in 1971 and 1972 consisting of seven dumps of 3,000 c.y. each of fine sand. The results of the bottom deposition program show that at no time during dumping operations on the bar did the accumulation of released material exceed 2 inches in depth during any one release. The maximum accumulation during the entire operation was 4 inches. The maximum accumulation occurred when the line of release was parallel to the current direction and the minimum when the line of release was perpendicular to the current direction. The tests were made under the following conditions: speed of vessel during release was 4 knots, the time required for discharge of the load was 5 minutes, and the current velocity was 1 knot over the entire water column.

(2) The U.S. Army Corps of Engineers, Portland District, established an experimental dredge disposal site in 1977 off the mouth of the Columbia River in about 85 feet of water. Six hundred thousand c.y. of sands were dumped, creating a conical pile about 5 feet high and 1,500 feet in radius. Sternberg, et al., estimates that the annual northward migration amounted to 825 c.y. of sediment moving 1,500 feet (about 0.2 percent of the total deposit). The dredged deposit of sand off Grays Harbor should thus be rather stable for long periods of time although the grain size of the material involved in the Columbia River test may be somewhat coarser than the material involved in the dredging of Grays Harbor.

(3) Bathymetric shape of the outer bar is convex seaward of the entrance to Grays Harbor. This shape indicates an offshore movement of material at the entrance. Ebb currents out of Grays Harbor estuary are the moving force that causes this offshore movement. Since construction of the jetties around the 1900's, the outer bar has deepened and moved seaward considerably as a result of the jetties concentrating ebb flows. Incoming flood flows on the outer bar are much weaker than the concentrated ebb flows, resulting in net seaward current on the bar. Limited field studies of currents out to 3.5 miles off the jetties show near bottom ebb current of 2.5 f.p.s. and near bottom flood currents of 0.5 f.p.s.

2.12 Special Features.

a. South Jetty. In the outer estuary, the South Jetty structure parallels the entrance channel for about 2 miles, with the outer mile of the jetty deteriorated to elevations -5 to -20 feet MLLW. The last rehabilitation on the jetty was in 1965 when 4,000 feet of the jetty was reconstructed. During the period 1940 to 1965, the channel migrated from the centerline area between North and South Jetty to the toe of the South Jetty and scour to depths of -70 feet MLLW undermined the structure, requiring the 1965 rehabilitaion. The strong tidal currents along the jetty are a continued threat to future undermining, and nourishment of the structure toe by disposal of dredge material sands is considered an important deterrent to undermining. The structure (including the submerged outer mile structure) functions very well in maintaining the Entrance and Bar reaches of the channel and its failure would have very significant adverse effects. Cost of rehabilitating the structure, assuming only a partial failure, would be on the order of $5 million per 1,000 feet of repair. The alternative to repair would be a concerted maintenance dredging program that might only provide a seasonal channel. In addition, erosion of South Beach would be extensive and the rate of ocean sediment transport into the estuary vastly increased.

b. North Jetty. North Jetty was rehabilitated in 1975 and is in excellent condition. The jetty functions very well in conjunction with South Jetty in maintaining the Entrance and Bar channels. The jetty also functions well in providing a stable North Beach shoreline.

c. Continued Planning and Engineering Studies. A number of environmental and engineering concerns still exist on the recommended project features. Main engineering related concerns include:

- rate and volume of sediment movement by direction and xtent for material deposited at the estuary and ocean disposal sites,

- whether feasible means exist to modify dredge equipment and dredge and disposal schedules to reduce adverse fishery impacts in a cost effective manner,

- the foundation condition of the upper estuary Cow Point area which might result in dredge difficulty problems, and

- condition of the South Jetty toe along the Entrance Channel side of the jetty.

Engineering and field studies will reexamine these concerns during CP&E studies. On-going related studies by others will assist in providing data for analyzing these concerns. Related studies and planned studies for CP&E are listed below:

o The U.S. Army, Coastal Engineering Research Center Field Data Collection Program, includes wave buoys off Grays Harbor, one about 30 miles offshore was installed November 1981 and a near shore gage is planned for installation in summer 1982. Analysis of data from these gages will help provide information useful in analyzing sediment movement and depth requirements on the bar.

o The National Ocean Survey plans an extensive estuary study of Grays and Willapa Harbors in summer 1982. In general, the study plan includes collection of salinity, temperature, tides, and currents throughout the estuaries. The data will better define currents and other hydraulic factors in Grays Harbor.

o Foundation exploration and bathymetric surveys will provide data for channel, turning basin, etc.; detailed layout; assist in evaluation of the condition of South Jetty; and provide additional information on dredge material characteristics.

o Current studies will be conducted at the ocean disposal sites (including alternative sites) to evaluate direction and velocity in sediment movement analysis.

o Further sediment studies will be conducted in an attempt to better understand movement of material released at proposed disposal sites. The studies include:

(1) sediment samples obtained at the proposed disposal sites (and alternatives) to evaluate existing bottom conditions, including the lateral extent of various types of bottom sediments;

(2) textural or tracer analysis of bottom sediments released during inner harbor disposal of dredged material during existing operations of the project; and

(3) suspended sediment analysis, hopefully in conjunction with a dredge disposal operation, to evaluate effects on water column quality.

2.13 Effects on Adjacent Shorelines. The major impacts on adjacent shorelines in the project area will be limited to the initial dredging. About 4 acres of shallow subtidal and intertidal areas will be disturbed in the initial dredging. No significant change in hydraulic conditions of any of the reaches of the channel is expected. Thus, little or no change in effects on adjacent shorelines due to waves, ship wakes, tidal regime, or current velocity is expected.

SECTION 3. COST ESTIMATE AND SCHEDULE

3.01 Project Cost Estimate. Detailed breakdown of project dredging, railroad bridge replacement, and other project costs is shown in tables D3-1 through D3-10, respectively.

Dredging and disposal costs are based upon a combination of clamshell with bottom-dump barge disposal and hopper dredge. Equipment and disposal site designations and costs by reach are shown in table D3-2. All dredge quantities include an allowance of an additional 2 feet of depth for advance maintenance and 2 feet for contractor overdepth allowance. Allowance for quantity contingencies are included in the 2 feet of contractor overdepth allowances. Costs for dredge side ranges required for the new widened channels (Bar through Crossover Reaches) are included in the unit prices for dredging. Utility relocation costs are minimal, as shown in table D3-8, and will be a non-Federal, local cost. Acquisition of about 4 acres of land is required for mitigation of shallow subtidals destroyed by dredging. Mitigation costs are discussed in the feasibility report and EIS and are detailed in table D3-6. Federal and non-Federal mitigation costs will be cost-shared in the same proportion as the basic navigation project. The costs for replacing the existing UPRR bridge will be apportioned according to the formula presented in section 6 of the Truman-Hobbs Act, as shown in tables D3-4 and D3-5. Costs for a fendering system on the U.S. highway bridge, immediately upstream of the railroad bridge, are shown in table D3-3. Fendering costs will be borne by non-Federal interests. Miscellaneous costs such as removal of old piling and structures are minor and included in dredging cost contingencies. Federal aids-to-navigation costs are shown in table D3-7. Plans for these aids were developed through intensive coordination with the USCG and Grays Harbor Pilots Association (see appendix B).

3.02 Operation and Maintenance. Federal responsibility for channel maintenance would include periodic maintenance dredging of various parts of the project area to insure that the full authorized dimensions of the channel are available to waterway users. The turning basins would also be maintained to their authorized dimensions. Portions of the channel would be dredged each year. Other aspects of the proposed project, such as costs for maintenance of North and South Jetties, would remain the same, with or without the proposed project.

Maintenance of the existing dredged channel is not expected to change significantly. However, dredging will now be required on the outer bar and at the new turning basins. Total maintenance dredging is not expected to be significantly higher than for the present project, except for maintenance on the outer bar. Existing and projected Federal and non-Federal maintenance requirements and costs are shown in tables D3-9 and D3-10. Maintenance dredging will probably be accomplished by hopper and/or clamshell, as shown in table 3-2 of the feasibility report. Equipment plan and schedule of work for maintenance dredging will be

reexamined during CP&E studies. Material will be deposited in the deep-water Point Chehalis and South Jetty sites except for the bar material which will be deposited at the 3.5-mile disposal site. Maintenance for the new bridge, utilities, etc., are non-Federal costs which should be equal to or less than what presently exists and are thus not itemized.

3.03 Design and Construction Schedule. The tentative design and construction schedule, assuming adequate funding and local sponsor assurances, is shown below. A more detailed bar graph is shown on plate 11. Construction timing, type of dredge equipment, and disposal locations for each reach are shown on plate 10. This dredging and disposal sequence will be investigated further during CP&E but was developed considering: (1) anticipated availability of dredge equipment, (2) environmental considerations, and (3) costs.

Item	Date
Completion of Division Engineer's Report	Nov 1982
Continued Planning and Engineering Studies	Oct 1984 1/
Initiate Plans and Specifications	Mar 1987
Advertise Construction	Feb 1988
Award Contract	Apr 1988
Complete Construction	May 1990

1/CP&E could begin as early as October 1983, assuming funding and continuation of planning approval. This would advance project completion by 1 year.

TABLE D3-1

SUMMARY OF PROJECT FIRST COSTS
October 1981 Price Level

	Federal	Non-Federal	Total
Outer Bar Reach - Cow Point Reach	$38,100,000	$525,000	$38,625,000
Upstream of Cow Point Reach	30,100,000	2,575,000	32,675,000
TOTAL (Rounded)	$68,200,000	$3,100,000	$71,300,000

SUMMARY OF TOTAL PROJECT AVERAGE ANNUAL COSTS1/
October 1981 Prices

	Federal	Non-Federal	Total
Outer Bar - Cow Point Reach	$5,062,000	$221,000	$5,283,000
Upstream of Cow Point Reach	2,576,000	221,000	2,797,000
TOTAL (Rounded)	$7,638,000	$442,000	$8,080,000

1/Discounted at an interest rate of 7-5/8 percent.

TABLE D3-2

DETAILED FEDERAL FIRST COSTS
October 1981 Price Level

Cost Account Number	Project Feature	Unit	Quantity	Unit Price	Amount
	(Outer Bar Reach to Cow Point Reach)				
06	MITIGATION1/				
	Dredge Modification	JOB	1	L.S.	$120,000
	Habitat Replacement	JOB	1	L.S.	136,000
	Contingency ± 25%				64,000
	Subtotal				$320,000
09	CHANNELS AND CANALS				
	1. Outer Bar Reach Dredge and Disposal (3.5 mi.)	C.Y.	4,000,000	$1.25	$5,000,000
	2. Entrance Reach Dredge and Disposal (S. Jetty)	C.Y.	200,000	$1.25	250,000
	3. South Reach Dredge and Disposal (Pt. Chehalis/S. Jetty)	C.Y.	3,400,000	$1.40	4,760,000
	4. Crossover Reach Dredge and Disposal (Pt. Chehalis/S. Jetty)	C.Y.	2,900,000	$1.80	5,220,000
	5. Moon Island Reach Dredge and Disposal (S. Jetty)	C.Y.	1,900,000	$2.35	4,465,000
	6. Hoquiam Reach Dredge and Disposal (3.5 mi.)	C.Y.	2,000,000	$3.00	6,000,000
	7. Hoquiam Reach Turning Basin Dredge and Disposal (3.5 mi.)	C.Y.	150,000	$3.00	450,000
	8. Cow Point Reach Dredge and Disposal (3.5 mi.)	C.Y.	400,000	$3.25	1,300,000

1/See table D3-6 for apportionment.

TABLE D3-2 (con.)

Cost Account Number	Project Feature	Unit	Quantity	Unit Price	Amount
	9. Cow Point Reach Turning Basin				
	Dredge and Disposal (silts @ 3.5 mi.)	C.Y.	100,000	$3.25	$325,000
	Dredge and Disposal (gravels @ Pt. Chehalis)	C.Y.	200,000	$5.00	1,000,000
	Contingency ± 20%				5,760,000
	Subtotal				$34,530,000
	Subtotal				$34,850,000
30	ENGINEERING AND DESIGN				$1,754,000
31	SUPERVISION AND ADMINISTRATION				1,196,000
	Subtotal - First Costs				$37,800,000
	Aids to Navigation (U.S. Coast Guard)				300,000
	TOTAL (Outer Bar to Cow Point Reach)				$38,100,000
	(Upstream of Cow Point Reach)				
02	RELOCATION 1/				
	Railroad Bridge Replacement	JOB	1	L.S.	$15,106,000
	Contingency ± 25%				3,826,700
	Subtotal				$18,932,700
06	MITIGATION 2/				
	Habitat Replacement	JOB	1	L.S.	$136,000
	Contingency ± 25%				34,000
	Subtotal				$170,000
09	CHANNELS AND CANALS				
	1. Aberdeen Reach Dredge and Disposal (3.5 mi.)	C.Y.	550,000	$3.50	1,925,000

1/See table D3-5 for apportionment.
2/See table D3-6 for apportionment.

TABLE D3-2 (con.)

Cost Account Number	Project Feature	Unit	Quantity	Unit Price	Amount
	2. South Aberdeen Reach Dredge and Disposal (S. Jetty)	C.Y.	1,150,000	$2.95	$3,392,500
	3. South Aberdeen Turning Basin Dredge and Disposal (S. Jetty)	C.Y.	150,000	$2.95	442,500
	Contingency ± 20%				1,160,000
	Subtotal				$6,920,000
	Subtotal				$26,022,700
30	ENGINEERING AND DESIGN				$1,992,300
31	SUPERVISION AND ADMINISTRATION				2,075,000
	Subtotal - First Costs				$30,090,000
	Aids to Navigation - (U.S. Coast Guard)				10,000
	TOTAL (Upstream Cow Point Reach)				$30,100,000
	TOTAL FEDERAL FIRST COSTS				$68,200,000

APPROVED

DATE 12 Mar. 1982

TABLE D3-3

DETAILED NON-FEDERAL FIRST COSTS
October 1981 Price Level

Cost Account Number	Project Feature	Unit	Quantity	Unit Price	Amount
	(Outer Bar Reach to Cow Point Reach)				
06	MITIGATION1/				
	Habitat Replacement	JOB	1	L.S.	$4,000
	Contingency ± 25%				1,000
	Subtotal				$5,000
09	CHANNELS AND CANALS				
	1. Hoquiam Reach-Berth Dredge and Disposal (S. Jetty)	C.Y.	50,000	$2.45	$122,500
	2. Cow Point Reach-Berth Dredge and Disposal (S. Jetty)	C.Y.	110,000	$2.55	280,500
	Contingency ± 20%				81,000
	Subtotal				$484,000
	Subtotal				$489,000
30	ENGINEERING AND DESIGN				22,000
31	SUPERVISION AND ADMINISTRATION				14,000
	TOTAL (Outer Bar to Cow Point)				$525,000
	(Upstream of Cow Point Reach)				
02	RELOCATION				
	1. Railroad Bridge2/ Replacement (U.P. Share)	JOB	1	L.S.	$532,970
	2. Highway 101 Bridge Fendering	JOB	1	L.S.	600,000
	3. Utility Relocations3/	JOB	1	L.S.	500,000
	Contingency ± 25%				408,330
	Subtotal				$2,041,300

1/See table D3-6 for apportionment.
2/See table D3-5 for apportionment.
3/See table D3-8 for cost break out.

TABLE D3-3 (con.)

Cost Account Number	Project Feature	Unit	Quantity	Unit Price	Amount
03	MITIGATION[1]				
	Mitigation	JOB	1	L.S.	$4,000
	Contingency ± 25%				1,000
	Subtotal				$5,000
09	CHANNELS AND CANALS				
	South Aberdeen Reach-Berth Dredging and Disposal (S. Jetty)	C.Y.	80,000	$2.95	$236,000
	Contingency ± 20%				46,000
	Subtotal				$282,000
	Subtotal				$2,328,300
30	ENGINEERING AND DESIGN				131,700
31	SUPERVISION AND ADMINISTRATION				115,000
	TOTAL (Upstream of Cow Point Reach)				$2,575,000
	TOTAL NON-FEDERAL FIRST COSTS				$3,100,000

1/See table D3-6 for apportionment.

TABLE D3-4

RAILROAD BRIDGE REPLACEMENT
October 1981 Price Level

Feature or Item	Unit	Quantity	Unit Price	Amount
STAGE 1				
Prefab Temporary Jump Span				
Structural Steel	LBS.	50,000	$1.25	$62,500
Timber Ties	L.F.	320	2.50	800
Plywood Decking	S.F.	800	0.80	640
Install Temporary Bents				
36-inch diam. Steel Pipes	L.F.	580	120.00	69,600
Structural Steel	LBS.	15,000	1.50	22,500
Remove Truss	LBS.	105,000	0.40	42,000
Install Jump Span	LBS.	61,000	1.00	61,000
Drive Sheet Piling No. 3	LBS.	1,000,000	0.80	800,000
Drive Sheet Piling No. 4	LBS.	1,000,000	0.80	800,000
Build Piers 3 and 4				
Structural Excavation	C.Y.	20,000	12.00	240,000
Structural Backfill	C.Y.	4,000	9.00	36,000
Gravel	C.Y.	240	20.00	4,800
Timber Piles Class "A" @ 50 feet	EA.	400	350.00	140,000
Concrete (Pumped from Shore)	C.Y.	8,000	300.00	2,400,000
Reinforcing Steel	LBS.	800,000	0.60	480,000
Prefab Span 4 w/o Tower	LBS.	143,000	1.25	178,750
Salvage Structural Steel	LBS.	105,000	0.02	-2,100
STAGE 1 Subtotal				$5,336,490
STAGE 2				
Float Our Span 4	LBS.	135,000	$0.50	$67,500
Dismantle Span 4	LBS.	135,000	0.35	47,250
Remove Jump Span	LBS.	61,000	0.50	30,500
Modify Jump Span	JOB	1	L.S.	15,000
Reinstall Jump Span	LBS	31,000	1.00	31,000
Remove Cofferdams	(Cost included with installation)			
Install Span 4	LBS.	143,000	0.50	71,500
Erect Left Lift Tower	LBS.	250,000	1.50	375,000
Concrete Counterweight	C.Y.	126	300.00	37,800
Remove Timber Fenders	JOB	1	L.S.	250,000
Prefab Span 2	LBS.	247,000	1.25	308,750
Right Lift Tower	LBS.	788,000	1.25	985,000
Prefab Lift Span	LBS.	2,205,000	1.00	2,205,000
Remove Temp Bent	JOB	1	L.S.	25,000
Modify Pier No. 5	JOB	1	L.S.	75,000
Salvage Structural Steel	LBS.	135,000	0.02	-2,700
STAGE 2 Subtotal				$4,521,600

TABLE D3-4 (con.)

Feature or Item	Unit	Quantity	Unit Price	Amount
STAGE 3				
Remove Jump Span	JOB	1	L.S.	$15,000
Remove Rest of Span 4	LBS.	240,000	$0.25	60,000
Dismantel Span 4	LBS.	240,000	$0.35	84,000
Remove Temp Bent	JOB	1	L.S.	25,000
Float Our Swing Span	LBS.	1,000,000	$0.10	100,000
Dismantel Swing Span	LBS.	1,000,000	$0.35	350,000
Modify Pier No. 2	JOB	1	L.S.	75,000
Remove Machinery	LBS.	340,000	$0.35	119,000
Remove Motors	JOB	1	L.S.	7,500
Salvage Structural Steel	LBS.	1,240,000	$0.02	-24,800
Salvage Machinery	LBS.	340,000	$0.02	-6,800
Salvage Motors	JOB	1	L.S.	-1,000
STAGE 3 Subtotal				$802,900
STAGE 4				
Install Timber Fenders	JOB	1	L.S.	$570,310
Concrete Counterweight	C.Y.	126	$300.00	37,800
Install Lift Span	LBS.	2,205,000	$0.15	330,750
Install Equipment				
Signaling, Communication and Interlock	JOB	1	L.S.	15,000
Emergency Eng. Gen. Set.	JOB	1	L.S.	50,000
Electrical Work	JOB	1	L.S.	500,000
Operating Machinery	JOB	1	L.S.	500,000
Sheaves, Shafts, & Bearings	JOB	1	L.S.	500,000
Wire Rope and Sockets	JOB	1	L.S.	100,000
Machinery Operations House	JOB	1	L.S.	60,000
Ties and Rail	L.F.	522	$200.00	104,400
Install Span 2 and Tower	LBS.	$1,035,000	0.25	258,750
Tower Hoods	JOB	1	L.S.	75,000
Deck Walkway	L.F.	522	$75.00	39,150
STAGE 4 Subtotal				$3,141,160
STAGE 5				
Cofferdams Piers 3 and 4	JOB	1	L.S.	$1,600,000
Remove Pier 3 Concrete	C.Y.	1,296	$75.00	97,200
Remove Pier 4 Concrete	C.Y.	1,000	$75.00	75,000
Remove Pier 3 Piling	EA.	171	100.00	17,100
Remove Pier 4 Piling	EA.	120	100.00	12,000
Remove Swing Span Guides	JOB	1	L.S.	30,000
Remove Rail and Ties	L.F.	552	10.00	5,520
STAGE 5 Subtotal				$1,836,820

TABLE D3-4 (con.)

Feature or Item	Unit	Quantity	Unit Price	Amount
SUMMARY:				
STAGE 1				$5,336,490
STAGE 2				4,521,600
STAGE 3				802,900
STAGE 4				3,141,160
STAGE 5				1,836,820
Subtotal				$15,638,970
Contingencies ±25 percent				3,961,030
Subtotal				$19,600,000
Engineering and Design				1,700,000
Supervision and Administration				1,900,000
TOTAL COST				$23,200,000

TABLE D3-5

UNION PACIFIC RAILROAD BRIDGE No. 53.33
GRAYS HARBOR, WASHINGTON

TABULATION OF PROPORTIONATE SHARE OF COST TO BE BORNE
BY THE UNITED STATE AND THE BRIDGE OWNER

Bridge Construction (includes removing old bridge)	$19,637,400
Right-of-Way	0
Engineering and Design	3,600,000
Total Estimated Cost of Bridge Replacement	$23,237,400
Less Salvage	-37,400
Cost of Replacement to be Apportioned	$23,200,000
Cost to be Borne by Bridge Owner:	
Direct and Special Benefits:	
Removing Old Bridge	$500,400 1/
Fixed Charges (engineering and inspection)	122,700 1/
Expectable Savings in Repair or Maintenance Costs	0 2/
Cost Attributable to Requirements of Railway and Highway Traffic	0 3/
Expenditure for Increased Carrying Capacity	0 3/
Expired Service Life of Old Bridge	32,570
Contingencies ± 25%	134,330
Cost to be Borne by Bridge Owner (3.4%)	$790,000
Cost to be Borne by the United States (96.5%)	$22,410,000

1/See next page for derivation.
2/Repair and maintenance costs of the new bridge would be about the same as the existing bridge.
3/The new bridge would be designed and constructed to current railroad bridge criteria for lane widths and carrying capacity.

TABLE D3-5 (con.)

BRIDGE OWNER'S SHARE OF REMOVING OLD BRIDGE

Age at Time of Removal:	79 years (new bridge would be completed in 1990)
Owner's Share:	79/100
Removal Cost:	$2,964,070
Owner's Share of Removal:	$2,341,615
Years Remaining:	21
Present Worth 7%:	0.2137
Owner's Present Liability:	$500,400

FIXED CHARGES TO BE PAID BY BRIDGE OWNER

Cost of Construction (excluding contingencies)	$19,238,970
Less Fixed Charges	-3,600,000
Total	$15,638,970
Owner's Share Less Fixed Char[illegible]s:	
Removing Old Bridge	$500,400
Expectable Savings in Repair or Maintenance Cost	0
Costs Attributable to Requirements of Railway and Highway Traffic	0
Expenditures for Increased Loading Capacity	0
Expired Service Life of Old Bridge .79 (78,630 - 37,400)	32,570
Total	$532,970
Fixed Charges by Owner $\frac{532,970}{15,638,970} \times 3,600,000$	$122,700

TABLE D3-6

MITIGATION1/
October 1981 Price Level

Item	Unit	Quantity	Unit Price	Amount
Dredge Modification	JOB	1	L.S.	$120,000
Acquire 4 Acres Land Near Junction City	SQ. FT.	180,000	$1.00	180,000
Prepare and Slope Site to Grade	JOB	1	L.S.	100,000
Contingency ± 25%				100,000
Subtotal				$500,000
Engineering and Design				26,000
Supervision and Administration				24,000
Total Mitigation Cost				$550,000
Total Federal Mitigation Cost (97.0%)				$539,000
Total Non-Federal Mitigation Cost (3.0%)				$11,000

1/Mitigation costs include: (1) mitigating 4 acres of lost shallow water fish feeding habitat through development of replacement habitat and (2) modifying dredge equipment to reduce the uptake and resulting mortality of juvenile and adult crabs. CP&E studies will determine if other suitable measures to reduce or mitigate the crab mortality should be taken.

TABLE D3-7

AIDS TO NAVIGATION
October 1981 Price Level

Reach	New Aids	Cost
Outer Bar	Bouy Modifications	$25,000
Entrance	1 Range	75,000
South Reach	None	0
Crossover	2 Ranges	100,000
Moon Island	1 Range	50,000
Hoquiam	1 Range	50,000
Cow Point	None	0
Aberdeen	None	0
South Aberdeen	Day Markers	10,000
TOTAL		$310,000

TABLE D3-8

UTILITY RELOCATION COSTS
OUTER BAR TO COSMOPOLIS

Owner	Utility 1/ Location	Utility Type	Date of Original Installation	Projected Life of Original Utility 2/	Unexpired 3/ Life of Present Utility	Projected 3/ Life of Relocated Utility	Total Estimated Cost of Relocation of Utility 4/	Project Cost 4/ Estimated Replacement Cost of Unexpired Life
I.T.T. Rayonier	HM 3.24	Waste Liquor Line and Submarine Cable	1964	25 years	NONE	25 years	$360,000	$0
I.T.T. Rayonier	HH 3.24	Rennie Island Outfall	1957	25 years	NONE	25 years	152,000	0
Pacific Northwest Bell Telephone	RM 0.0	Four Submarine Cables	1960	50 years	20 years	50 years	375,000	150,000
City of Aberdeen	RM 0.0	14" Waterline (East)	1974	80 years	64 years	80 years	167,000	135,000
City of Aberdeen	RM 0.0	Sewer Pressure 14" Main	1958	80 years	48 years	80 years	167,000	100,000
City of Aberdeen	RM 0.05	14" Waterline (West)	1958	80 years	48 years	80 years	167,000	100,000
Cox Cablevision	RM 0.02	T.V. Submarine Cable	1968	15 years	NONE	20 years	15,000	0
Dept. of Highways	RM 2.7	Four Submarine Cables	1953	50 years	13 years	50 years	52,000	15,000
					Direct Construction Costs		$1,455,000	$500,000
					Contingencies		365,000	125,000
					Engineering and Design		90,000	90,000
					Supervison and Administration		70,000	70,000
					TOTAL		$1,980,000	$785,000

1/HM=Harbor Mile
RM=River Mile - Chehalis River
0.0=Union Pacific Railroad Bridge
2/At time of original installation
3/Based on 1990 Relocation
4/Based on Oct 1981 Prices: Relocated to 54 MLLW.

TABLE D3-9

FEDERAL MAINTENANCE COSTS
October 1981 Price Level

Reach	Existing Project (1,000 c.y./$1,000)	Recommended Plan (1,000 c.y./$1,000)
OUTER BAR TO COW POINT:		
Outer Bar	0/$0	800/$1,000
Entrance	0/0	0/0
South	400/540	450/608
Crossover	400/700	450/787
Lower Moon Island	120/240	160/320
Upper Moon Island	30/69	40/96
Hoquiam	50/118	100/245
Cow Point	150/367	200/510
Subtotal	1,150/$2,034	2,200/$3,566
Contingencies ± 20%	406	713
E&D, S&A ± 15%	326	594
Subtotal	$2,802	$4,873
Aids to Navigation	28	37
TOTAL	$2,830	$4,910
UPSTREAM OF COW POINT:		
Aberdeen	50/$127	50/$135
South Aberdeen	50/140	100/295
Subtotal	100/$267	150/$430
Contingency ± 20%	54	86
E&D, S&A ± 15%	47	71
Subtotal	$368	$587
Aids to Navigation	2	3
TOTAL	$370	$590
TOTAL Federal Maintenance Costs	$3,200	$5,200

INCREMENTAL FEDERAL MAINTENANCE COSTS ($1,000)
(October 1981 Price Level)

Outer Bar to Cow Point Reach	$2,080
Upstream of Cow Point Reach	220
TOTAL INCREASE AVERAGE ANNUAL FEDERAL MAINTENANCE COSTS	$2,300

TABLE D3-10

NON-FEDERAL MAINTENANCE COSTS
October 1981 Price Level

Reach	Existing Project (1,000 c.y./$1,000)	Recommended Plan (1,000 c.y./$1,000)
OUTER BAR TO COW POINT:		
Hoquiam	35/$82	40/$94
Cow Point	300/735	350/857
Subtotal	335/$817	390/$951
Contingencies ± 20%	163	189
E&D, S&A ± 15%	150	170
TOTAL	$1,130	$1,310
UPSTREAM OF COW POINT:		
South Aberdeen	35/$98	40/$112
Contingencies ± 20%	20	23
E&D, S&A ± 15%	17	21
TOTAL	$135	$155
TOTAL Non-Federal Maintenance Costs	$1,265	$1,465

INCREMENTAL NON-FEDERAL MAINTENANCE COSTS ($1,000)
(October 1981 Price Level)

Outer Bar to Cow Point Reach	$180
Upstream of Cow Point Reach	20
TOTAL INCREASE AVERAGE ANNUAL NON-FEDERAL MAINTENANCE COSTS	$200

DATE
ILME